Finding Headspace in Green Workplaces:

The restorative value of science park open space

Kathryn Gilchrist

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Heriot-Watt University

School of the Built Environment

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ABSTRACT

Person-environment relationships in five urban-fringe science parks in central Scotland were investigated through the application of a mixed method case study design. The study sought to explore the impact of greenspace at these knowledge-sector workplaces on employee wellbeing, with particular focus on restorative effects of viewing and spending time in green environments. The thesis also aims to develop understanding of how workers at these sites engage with, and relate to, the outdoor environment at their workplace. Both quantitative and qualitative data were collected; the former through an online questionnaire (n=366), and the latter through in-depth semi-structured walking interviews (n=16) conducted on and around the sites.

This research is the first to provide evidence of wellbeing benefits of greenspace in the context of UK workplaces. Its focus on the landscape of science parks is of particular relevance given the prominence of this development model in planning policy to promote regional economic growth, as well as the central role of employee functioning in the productivity of innovative knowledge-sector businesses. The insights gained through the research point to a number of conclusions for the planning and design of future business sites at the urban fringe. The research also makes an original contribution to the international research on restorative environments in its exploration of how different types and designs of open space impact on the wellbeing of workers and, in particular, how individual factors influence responses to elements of open space design and management in the workplace context.

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CONTENTS

Chapter 1: Introduction

1.1 Background

1.1.1 Environment and health

Environmental factors are increasingly recognised for their role in influencing human health. Although improving health through the regulation of the built environment has been a goal of town planning since its inception (Corburn 2004, Cullingworth and Nadin 2006), during the latter part of the 20th century consideration of health had become more marginal amongst the myriad aims of planning policy. In the UK context this may be seen as a result of improved housing standards and the advent of statutory pollution control regimes, meaning that the traditional environmental health challenges resulting from poor sanitation and air pollution in urban areas that had arisen as a result of the industrial revolution were no longer key policy drivers. More recently, new challenges to population health in developed nations - namely rising rates of obesity, linked to a range of 'lifestyle diseases', and common mental health disorders - along with concern about persisting social inequalities in health - are bringing health back into the foreground (Northridge et al. 2003, de Vries 2010, Ward Thompson 2011).

The biomedical model of health which dominated for much of the 20th century places emphasis on the biological causes of ill-health in individuals. This model is concerned with morbidity and mortality and their direct causes; injury, infection, toxicity and genetics take priority in this view of the body as a largely self-contained biological system. As such, it focuses on the individual and frames health in terms of the absence of disease. Towards the end of the century a new social model of health gained more prominence. Dahlgren and Whitehead's (1991) influential social model (figure 1.1) takes a less restricted view of the determinants of health by incorporating social and environmental factors. Amongst the factors outlined in this model is the recognition of the influence of the work environment on health.

The social model of health, in conjunction with growing influence of social-ecological perspectives in health promotion (Stokols 1992) represent a paradigmatic shift towards a more integrative understanding of the biological, psychological, social and environmental factors influencing health. These models also align with a more positive concept of health by considering factors that promote good health as well as those responsible for illness, in line the World Health Organisation's definition of health as 'a

state of complete physical, mental and social well-being and not merely the absence of disease or infirmity' (WHO 1948).

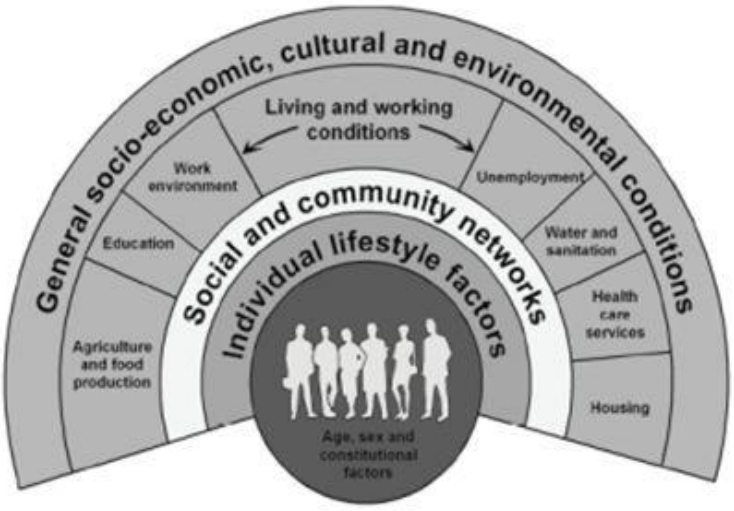


Figure 1.1: The social model of health (Dahlgren and Whitehead 1991).

Accompanying this transition, a growing body of empirical research has sought to develop the evidence base on the role of the physical environment (particularly in urban areas) for population health, and on how an understanding of salutogenic (health supporting) environments may be applied in the delivery of public health objectives. This research stems from a number of academic disciplines; from urban studies, social geography, epidemiology, to environmental psychology, and is increasingly interdisciplinary in nature. In Scotland this body of research has influenced policy development on tackling health inequalities, as seen in the Scottish Government's flagship policy on environment and health Good Places, Better Health (Scottish Government 2008b) and in the approach of the Ministerial Taskforce on Health Inequalities in their report Equally Well (Scottish Government 2008a). This shift in research and policy has led to a broadening of the onus for health promotion to encompass planning, architecture, and landscape architecture as well as the health professions.

1.1.2 Spatial associations between greenspace and health

Building on a long tradition of urban greenspace provision as a public good supportive of population health e.g. by the urban parks and garden cities movements (Ward Thompson 2011, Olmsted 2013, Macfadyen 2013), much recent research exploring links between the physical environment and health has focused on the role of greenspace. At the population scale, the availability of greenspace has been found to be associated with physical health outcomes such as self-reported health (de Vries et al.

2003, Maas et al. 2006, 2008, 2009a, Mitchell and Popham 2007, Sugiyama et al. 2008, Stigsdotter et al. 2010, van Dillen et al. 2012) and objective measures such as mortality rates and cardiovascular disease (Mitchell and Popham 2008, Maas et al. 2009b, Richardson and Mitchell 2010). There is particularly strong evidence of positive effects of greenspace availability on mental health and wellbeing. For example, analyses of large scale surveys have found associations between greenspace levels or greenspace use and risks of poor mental health derived from self-report scales (de Vries et al. 2003, Sugiyama et al. 2008, Maas et al. 2009a, Mitchell 2012, van Dillen et al. 2012, White et al. 2013b), self-reported stress (Grahn and Stigsdotter 2003, Nielsen and Hansen 2007, Stigsdotter et al. 2010), and objective rates of depression and anxiety (Maas et al. 2009b). Patterns of production of the stress hormone cortisol have also recently been found to be associated with greenspace availability in a study of non-working residents of a deprived urban area in Scotland (Ward Thompson et al. 2012, Roe 2013). The research has, on the whole, tended to focus on measures of poor mental health rather than positive wellbeing. Nevertheless, there is evidence from UK panel data that subjective wellbeing is higher when living in greener areas (White et al. 2013b), although recent research on Scottish population data found no clear associations between positive wellbeing and either greenspace availability or use of greenspace for physical activity (Mitchell 2012).

Spatial correlations in the built environment are, of course, vulnerable to a number of potential confounding factors. Greenspace provision varies with socio-economic deprivation, with those in the most deprived areas tending to experience less access (see e.g. CABE Space 2010, Greenspace Scotland 2012). At the same time, the health inequalities between deprived and affluent groups (within both developed and developing countries globally) are well documented (Braveman and Tarimo 2002). However, the relationships between greenspace and health found in a number of developed countries including the UK, the Netherlands, Denmark, Sweden and Australia are not spurious associations reflecting spatial patterns of socio-economic health inequality; the studies cited above each controlled for socio-economic factors at an individual or area level. Furthermore, studies have shown that it is those living in the most deprived areas that appear to benefit the most from access to greenspace (de Vries et al. 2003, Mitchell and Popham 2008, Maas et al. 2009b).

Associations between greenspace access and health indicators have been also been observed when controlling for level of urbanity (de Vries et al. 2003, Maas et al. 2006,

Mitchell and Popham 2008), population density (Mitchell and Popham 2008), housing type (Nielsen and Hansen 2007, White et al. 2013b), and garden access (de Vries et al. 2003).

Finally, recent longitudinal research by White et al. (2013b) has gone some way to overcoming the limitations of the almost exclusively cross-sectional evidence base to establishing a causal basis to the observed relationships between greenspace and health. Although as discussed above, many potential confounding factors had already been accounted for in previous research, White et al.'s panel data analysis has allowed personality traits (and thus potential self-selection biases relating to e.g. orientations towards nature and urban preferences) to be controlled. Their analysis indicates that when the same individuals were living in greener areas they reported greater subjective wellbeing and less mental distress than when living in less green areas, after accounting for changes in life circumstances. This relationship held regardless of whether or not gardens were included within the greenspace measure. Given these strong indications of a causal effect of greenspace on health, the following section goes on to examine the mechanisms that may be responsible for greenspace effects on health.

1.1.3 Potential causal mechanisms

There are several mechanisms that may link green environments and positive health outcomes. Guidance on Health Impact Assessment of Greenspace (Health Scotland et al. 2008) groups these 'pathways to health' into four categories:

- Direct protection from environmental exposures
- Promoting physical activity
- Promoting restoration, relaxation and reduction in stress
- Promoting social interaction and cohesion

The primary focus of this study is the restorative benefits of greenspace and natural environments, which are particularly relevant in the context of the knowledge-sector workplaces that this research is concerned with (see section 4.2.4). However, given the complex nature of the relationship between engagement with greenspace and wellbeing, it is not possible to study the restorative functions without also considering how they may interact with (and be confounded by) other benefits related to wellbeing outcomes. The direct protective effects of greenspace and vegetation e.g. mitigating air pollution, contributing towards flood prevention, and regulating microclimate are important

ecosystem services which have indirect implications for human wellbeing (Pretty et al. 2011). These effects are not, however, included in the scope of the present study, which focuses on the psychological benefits of greenspace in peri-urban workplaces. In this context, the three remaining pathways relating to physical activity, psychological restoration and social interaction, are considered particularly pertinent and have received the greatest research attention with respect to mental health and wellbeing.

Promoting physical activity

There is evidence that where people have good access to green space, levels of physical activity are higher and obesity rates are lower (Giles-Corti et al. 2005, Ellaway et al. 2005, Coombes et al. 2010, Mytton et al. 2012). Higher levels of physical activity are beneficial for mental as well as physical health (see e.g. Scully et al. 1998, Hamer et al. 2009). Public open space offers the opportunity for physical activity by providing a setting where it can take place - one which is open to all and free to use. Informal activities like walking, running and cycling are common uses of open space, and some types of greenspace (e.g. parks and recreational grounds, allotments and community gardens) may offer facilities allowing particular sports or gardening to take place. As well as offering the opportunity, the presence of greenspace or street trees has been seen to increase people's motivation to get outdoors and be active (Brown 2010). People are more positively oriented towards walking when attractive green routes are available (Adkins et al. 2012). Linear green spaces like those that exist along canals and disused railways lines form valuable active travel routes, and the simple presence of street trees can add to the walkability of the urban environment itself (Takano et al. 2002).

Attempts to isolate the relative contribution of physical activity to spatial associations between greenspace and health provide a mixed picture. Whilst one study in Australia found that walking explained associations between neighbourhood greenness and physical health (Sugiyama et al. 2008), the Dutch study by Maas et al. (2008) found no evidence that physical activity mediated the relationship found between greenspace availability and self-reported health. Apparent benefits to self-reported mental health and stress levels cannot be fully explained by increased levels of physical activity in areas with more greenspace (Sugiyama et al. 2008, Fan et al. 2011).

Promoting restoration, relaxation and reduction in stress

Experimental research has demonstrated independent psychological effects of environment over and above those of physical activity (e.g. Hartig et al. 2003, Pretty et

al. 2005, Park et al. 2010, Aspinall et al. 2013). These effects can help to explain associations between greenspace and both mental and physical health, as well as providing an explanation for increased motivations to take part in 'green exercise' as opposed to exercise indoors or outdoors in environments devoid of nature. In a study by Pretty et al. (2005), exercising whilst viewing scenes of a pleasant green environment resulted in greater blood pressure reductions than viewing other environments or a blank screen, and pleasant scenes in general resulted in significant boosts to self-esteem whereas unpleasant environments did not. These types of independent effects arising from the perception of the physical environment are the focus of the multi-disciplinary field of 'restorative environments' research. Restorative environments are those that promote (and not just permit) restoration, which in this context has been defined as 'the process of recovering physiological, psychological and social resources that have become diminished in efforts to meet the demands of everyday life' (Hartig 2007:164). Natural environments are often found to be particularly effective in promoting restoration. Although restoration is sometimes framed simply in terms of relaxation, it more often refers more specifically to psychological processes relating to stress relief and/or attention restoration (recovery from mental fatigue). These processes (and the empirical evidence relating to them) are discussed in detail in chapter 2.

Promoting social interaction and cohesion

Public greenspaces are often places that friends and family visit together (Peters et al. 2010, O'Brien and Morris 2013), and so are venues in which existing relationships may be enjoyed and reinforced. Public open spaces can also serve as civic spaces, described by the Project for Public Spaces as:

> *'...an extension of the community. When they work well, they serve as a stage for our public lives. If they function in their true civic role, they can be the settings where celebrations are held, where social and economic exchanges take place, where friends run into each other, and where cultures mix'* (Project for Public Spaces undated).

Attractive open spaces can encourage people outdoors, increasing the likelihood of social interaction and aiding the development of neighbourhood social ties (Gehl 1987, Coley et al. 1997, Kuo et al. 1998). Even modest verbal or non-verbal interactions with neighbours or others in passing, or simply seeing 'familiar strangers' (Milgram 1977, Mote and Whitestone 2011) could contribute to a sense of community and security.

Public parks are also inclusive environments where people of different backgrounds can interact, further facilitating social cohesion (Ward Thompson 2002, Seeland et al. 2009, Peters et al. 2010). These interactions between family members, friends, neighbours and familiar and unfamiliar strangers may all boost an individual's social capital. Putnam (2000:19) has defined social capital as 'connections among individuals - social networks and the norms of reciprocity and trustworthiness that arise from them'. Although many definitions and measures of the construct exist (see Portes 1998, Carpiano 2006), many studies have demonstrated that, in this broad sense, social capital plays a central role in influencing health and wellbeing (Lomas 1998, Ryan and Deci 2001, Helliwell 2003, Powdthavee 2008).

Several studies provide evidence for social capital as a mediating factor linking neighbourhood greenspace availability and measures of health and wellbeing (Sugiyama et al. 2008, Maas et al. 2009a, Fan et al. 2011). In each of these studies the measures of social capital (variously social support, social coherence, and social interactions) helped to explain associations between greenspace and wellbeing but could not fully account for them. The balance of evidence from these studies also points more towards sense of community and perceived levels of social support rather than social interactions with neighbours per se as the important dimensions of social capital in this relationship. Potential confounding effects of housing density on relationships between greenspace availability and social capital and related concepts should also be noted; less dense communities have more greenspace (Fuller et al. 2008), and less dense communities have been found to display greater social sustainability in terms of attachment, interactions and safety, including when adjusting for greenspace availability (Bramley et al. 2008).

1.1.4 Mental health and wellbeing

Issues of mental health and wellbeing are of increasing concern in modern society. By far the most common mental disorders (CMDs) are depression and anxiety, rates of which have increased in many countries in recent decades (Layard 2011). In the UK around 1 in 5 adults show indications of mental ill health, as measured by the GHQ12 diagnostic tool (Self et al. 2012). At the same time antidepressant prescribing continues to grow; it is estimated that more than 10% of adults in Scotland are taking antidepressants on a daily basis (ISD Scotland 2011). There is evidence that depression is not only more commonly diagnosed but also more prevalent in affluent countries (Bromet et al. 2011). At the same time there is a growing sense amongst researchers

across a number of disciplines that wellbeing may be seen as a 'collateral casualty of modernity' - that wellbeing is being compromised in favour of individualism and materialism in modern consumer societies (Carlisle et al. 2009).

In a general sense, issues of mental and psychiatric health are often discussed under the broad umbrella of 'wellbeing', however it is necessary at this stage to clarify some of the distinctions within this broad and unwieldy concept. Measures of mental health (e.g. the GHQ12 and the DSM-IV questionnaires) focus on measuring psychological distress and were developed to aid the diagnosis of mental health disorders. Research on mental health has traditionally focused on treating or reducing the incidence of poor mental health (Ryan and Deci 2001). Wellbeing, on the other hand, is a more positively oriented concept, of which there are multiple contested definitions and dimensions. For clarity, the terms 'mental health' and ''wellbeing' will therefore used separately in this thesis to denote these two distinct orientations.

Within the psychological literature, there are two leading theoretical perspectives on wellbeing - the hedonic and the eudaimonic (see e.g. reviews by Ryan and Deci 2001, Keyes and Annas 2009, Carlisle et al. 2009). The hedonic approach considers wellbeing in terms of how people feel; referred to by some as 'subjective wellbeing' (SWB). SWB is measured in terms of positive and negative emotion, or 'affect', and individuals' ratings of overall life satisfaction. The eudaimonic approach, on the other hand, considers not just pleasure and satisfaction but also psychological functioning, meaning and self-actualisation. This perspective emphasises the concept of 'psychological wellbeing' (PWB) which is often measured in terms of six dimensions proposed by Ryff (1989) - autonomy, environmental mastery, personal growth, positive relations, purpose in life, and self-acceptance. These two perspectives may be usefully considered as emphasising two overlapping dimensions of overall positive wellbeing, (or 'flourishing') rather than as competing theories (Ryan and Deci 2001, Keyes and Annas 2009). Within the growing field of positive psychology, wellbeing is discussed in terms of 'flourishing' and 'languishing'. Flourishing is characterised as a combination of both 'feeling good and 'functioning well' (Keyes and Annas 2009). At the other end of the continuum is 'languishing' (where both hedonic and eudaimonic wellbeing are low), which is related to poor mental health (Keyes and Annas 2009). From the positive psychology perspective, functioning well - not just as an individual but within the context of society - forms a facet of eudaimonic wellbeing referred to as 'social

wellbeing'. Social wellbeing has been defined as 'the appraisal of one's circumstance and functioning in society' (Keyes 1998).

The concept of wellbeing has gained currency in the economic literature in recent years due to observations that in many developed nations levels of happiness (measured in terms of ratings of life satisfaction) have barely changed throughout the latter half of the 20th century, despite large increases in incomes and living standards (Easterlin 1974, Layard 2011, cf. Stevenson and Wolfers 2008). In the UK, concern about this 'paradox of affluence' and the influence of high-profile proponents of 'happiness economics' like Richard Layard, Joseph Stiglitz and Amartya Sen have driven a recent policy interest in wellbeing (NEF 2012). The Scottish Government's National Performance Framework, launched in 2007 to track progress on its strategic objectives of creating a Wealthier and Fairer, Smarter, Healthier, Safer and Stronger, and Greener Scotland, includes positive wellbeing amongst its performance indicators (Scottish Government 2012b). In 2010 the UK government launched its Measuring National Well-being Programme to develop a suite of indicators of national progress based on wellbeing rather than solely economic measures like GDP (ONS 2013). Although happiness economics as a basis for public policy has been criticised for its narrow focus on subjective wellbeing and the insensitivity of life satisfaction as an indicator (Johns and Ormerod 2007, Seligman 2011), it may be argued that in the UK context the policy approach has been to take a wider view. The Scottish Government's indicator of wellbeing uses the Warwick-Edinburgh Mental Well-Being Scale (WEMWBS), which measures elements of both hedonic and eudaimonic wellbeing (see section 5.3.3 for further discussion of this measure). The UK government's wellbeing measures include a wide range of indicators that extend beyond simple measurement of life satisfaction to encompass many potential determinants of wellbeing relating to the built and natural environment as well as social and economic indicators.

1.2 Research problem

The majority of research investigating the health and wellbeing benefits of greenspace and nature has focused on the home and recreational contexts. However, many people spend more of their waking hours at work than at home. Also, at northern latitudes the workplace may be the only context in which 9-to-5 office workers have the opportunity to spend time outdoors on winter weekdays during daylight hours. There is therefore clear potential for health and wellbeing benefits to be gained from access to greenspace in the context of the workplace.

If access to greenspace at work can positively influence employee mental health and wellbeing, the implications are far-reaching. Poor mental health costs businesses dearly in terms of sickness absence, reduced productivity and turnover; it is estimated that mental ill-health costs UK businesses a total of £26 billion per year (Mind and CIPD 2011). Amongst non-manual workers in the UK, mental health issues are the second most common cause of sickness absence after minor illnesses (which include colds and flu etc.), and are the single most common cause of long term absence in both manual and non-manual workers (CBI 2011, CIPD 2011). Whilst mental ill-health places a burden on employers, positive wellbeing can carry organisational benefits. The 'happy-productive worker hypothesis' proposes that those who are more satisfied in their jobs are also more productive and more engaged employees. There is evidence that higher subjective wellbeing and job satisfaction at work are positively related to job performance, productivity, and organisational citizenship (e.g. being cooperative, friendly and trustworthy), and are negatively related to employee turnover and absenteeism (Judge et al. 2001, Harter et al. 2003, Diener and Seligman 2004). Promoting wellbeing in the workplace and mitigating work-related stress may therefore have wide-ranging consequences, not just for workers themselves but also for the productivity of businesses. This is increasingly being recognised by employers; a 2011 survey of UK businesses found that two-thirds of the public sector and one-third of the private sector organisations surveyed have an employee wellbeing strategy in place (CIPD 2011).

Environmental factors affecting wellbeing at work and job satisfaction are the subject of a significant amount of research in the environmental psychology and the design disciplines, however this research has almost exclusively focused on the interior workplace environment. Consideration of the potential effects of the outdoor setting on those working in office buildings has been for the most part limited to discussions of the importance of windows, and often the actual content of the window view (what is seen) is not directly addressed. Despite this, it appears from the few studies which do focus on the exterior (and what can be seen of it from inside) that the outdoor environment is significantly related to the wellbeing of workers (see chapter 3 for discussion). To the author's knowledge there has been no research on the value of workplace greenspace for employee wellbeing in the UK context. Also, few of the international studies have investigated the impact of having *direct access* to usable greenspace from the workplace on wellbeing and mental health; the majority have focused solely on views. Further

research on the psychological value of outdoor green environments at work is therefore warranted.

This line of enquiry is particularly salient given the fact that a great deal of new commercial property development now occurs at urban-fringe business sites like science parks and business parks, where low density development and a high quality environment are prioritised. We might hypothesise that there is a great deal of scope in these workplaces for employees to benefit from the restorative effects of nature by spending time outdoors in the open space there and being able to look out on it from inside the buildings.

Campus-style business sites like science parks are developed to accommodate knowledge sector businesses, to whom employee wellbeing may be of particular importance since the productivity of such businesses is reliant upon human capital and effective psychological functioning (as discussed further in section 4.2 of the thesis). Furthermore, science parks may play an important role in economic development at the regional and national scale. Supporting innovation and growing the knowledge economy is seen as a key policy objective for national and regional economic development in Scotland, as outlined in a number of policies e.g. *Science for Scotland*, the *Government Economic Strategy* and the cities strategy *Scotland's Cities: Delivering for Scotland* (Scottish Government 2008c, 2011a, 2011b). This reflects a global shift towards knowledge-based economies in the wake of widespread deindustrialisation and globalisation (Brinkley 2006). Sectors targeted in Scotland have included the life sciences, electronics and biotechnology, with planning policy promoting cluster development and science parks as levers to attract investment from these sectors and to incubate new innovation-led companies (see chapter 4). The activity of these industries centres on research and development - activities which place high cognitive demands on employees. Coupled with the fact that work is often a major source of daily hassles and stress, this means that the employees of science park workplaces may be a particularly relevant population in which to study the restorative benefits of workplace greenspace. There is, however, little existing research on this type of private open space and none on how they are used by employees, not least the benefits (or otherwise) they may offer in terms of wellbeing.

1.3 Research design

1.3.1 Aim and Objectives

Project aim

The overarching aim of the research is to investigate the restorative value of science park open space and the potential wellbeing benefits that exposure to greenspace in this context may offer employees.

Objectives

In fulfilling this aim the following objectives were proposed:

1. To review theories and empirical evidence on the restorative benefits of greenspace, with particular focus on the workplace context.

2. To explore employee engagement with the outdoor environment at science parks and the factors influencing employees' use and views of the greenspace.

3. To test for evidence of cumulative effects of exposure to science park greenspace on employee wellbeing.

4. To analyse employees' perceptions and lived experience of the open space on and around science park sites to gain an understanding of the restorative potential of the outdoor environment at these workplaces.

5. To draw conclusions and recommendations for the planning and design of knowledge sector business sites to support employee wellbeing.

1.3.2 Conceptual model

Figure 1.2 illustrates the conceptual model used to guide the research. This high-level model was developed from the literature on greenspace and wellbeing discussed above in sections 1.1.2-1.1.3 and that reviewed in chapter 2. It illustrates the types of exposure to greenspace employees may experience during the working day and the key pathways considered to play a part in explaining associations between greenspace and wellbeing. Although the focus of this study was on the restorative value of workplace greenspace it was necessary to consider this in relation to the potential wellbeing benefits arising as a result of physical activity and social interaction in science park open space, given the complexity of the relationship between natural environments and

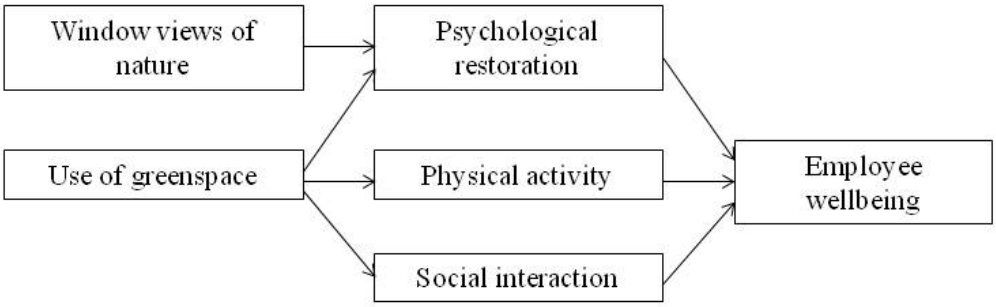


Figure 1.2: Conceptual model of the relationship between workplace greenspace exposure and employee wellbeing.

human wellbeing and the difficulty of distinguishing between these (potentially interrelated) benefits of greenspace use.

1.3.3 Methodology

A mixed method case study design was adopted for this research. The case study sites in the study comprised five science parks located in Scotland's central belt. The rationale guiding site selection and descriptions of the sites and their settings are detailed in Chapter 4. Chapter 5 goes on to discuss the methods of data collection used.

Quantitative data was collected through an online survey of 366 employees distributed across the case study sites. The survey questionnaire collected quantitative data on:

- respondents' use and views of the open space, including reported drivers and barriers to spending time outdoors during the working day (addressing objective 2);
- information on wellbeing, job satisfaction and sickness absence, as well as relevant background information to enable statistical modelling of the potential cumulative benefits of exposure to workplace greenspace (in fulfilment of objective 3); and
- employees' perceptions of the open space and self-reported restoration outcomes experienced during outdoor breaks (in relation to objective 4).

The data were analysed using a mixture of descriptive statistics, parametric and non-parametric tests, and regression models. In order to add greater depth to the understanding of person-environment relationships in the science park context a qualitative study was also conducted. Semi-structured walking interviews (or 'go alongs') were performed in situ with sixteen participants who had previously responded to the employee survey. Audio recordings of the interviews were transcribed and analysed to identify key themes relating to objectives 2 and 4 above.

This mixed method research project adopted a pragmatic approach. Pragmatism eschews the 'incompatibility thesis' - the position that quantitative and qualitative research paradigms are epistemologically antagonistic - and instead prioritises recognition of the value of drawing on the strengths of each, compensating for limitations of the other (Onwuegbuzie and Leech 2005, Burke Johnson et al. 2007). From the pragmatic perspective the choice of methods should be driven by the research questions and consideration of 'what works' to answer them (Burke Johnson and Onwuegbuzie 2004, Onwuegbuzie and Leech 2005). To this end, the quantitative and qualitative studies were intended to complement one another in order to produce robust quantitative findings supported by an in-depth understanding of employees' relationships with the spaces in question.

1.4 Original contribution

This research is the first UK study to examine relationships between workplace greenspace and employee wellbeing. As such it complements the limited existing international research, which has primarily focused on visual access to greenspace defined in broad terms, and attempts to fill a gap in the understanding of the wellbeing impacts of direct, immersive, experiences of greenspace in the workplace context. It also adds to the under-researched topic of employee engagement with workplace greenspace and the factors influencing decisions to spend time outdoors during the working day. In its specific focus on science parks, the research takes a social-ecological approach yielding conclusions high in external validity (see discussions in sections 2.3 and 3.4.1). These conclusions will be of value to practitioners involved in the planning and design of science parks and other campus-style urban fringe business sites, providing evidence to inform the development of knowledge-sector workplaces supportive of employee wellbeing.

1.5 Thesis structure

The thesis is structured around the five objectives set out in section 1.2.1 above. Chapter 2 presents a review of the literature on restorative environments and associations between greenspace and wellbeing, with chapter 3 going on to examine the evidence on employee engagement with greenspace in the workplace context and its potential benefits. Together, chapters 2 and 3 address objective 1. A detailed account of the methodology can be found in chapters 4 and 5. Chapter 4 focuses on the science park development form and the project's case study design, with chapter 5 setting out the

methods of data collection used. Objectives 2, 3 and 4 are addressed in chapters 6, 7 and 8 respectively, which present the results of the research. Chapter 9 summarises the key conclusions of the research and draws the findings together to provide a set of recommendations for the planning and design of science parks in fulfilment of the fifth and final objective.

Chapter 2: Restorative environments - research and theory

2.1 Introduction

Restoration is taken here to mean 'the process of recovering physiological, psychological and social resources that have become diminished in efforts to meet the demands of everyday life' (Hartig 2007). This chapter presents a review of theories and empirical evidence on the restorative effects of greenspace. The chapter begins by introducing the theoretical framework, explaining how contact with nature can result in restoration benefits to individuals (section 2.2). These benefits include a range of positive psychological and physiological outcomes, which are usefully considered in terms of a) the discrete benefits of a single exposure to a restorative environment (discussed in sections 2.2.1 and 2.2.2) and b) the cumulative benefits accrued through regular or repeated exposures (section 2.3) (Hartig 2007). The chapter then goes on to explore what restorative environments research reveals about the key factors that influence whether a particular person-environment interaction will result in restoration and, if so, the magnitude of the benefit derived. These sources of variation in restoration outcomes are discussed with reference to three constituent categories: 1) environment factors, 2) person factors, and 3) contextual factors. This framework is illustrated in figure 2.1 below:

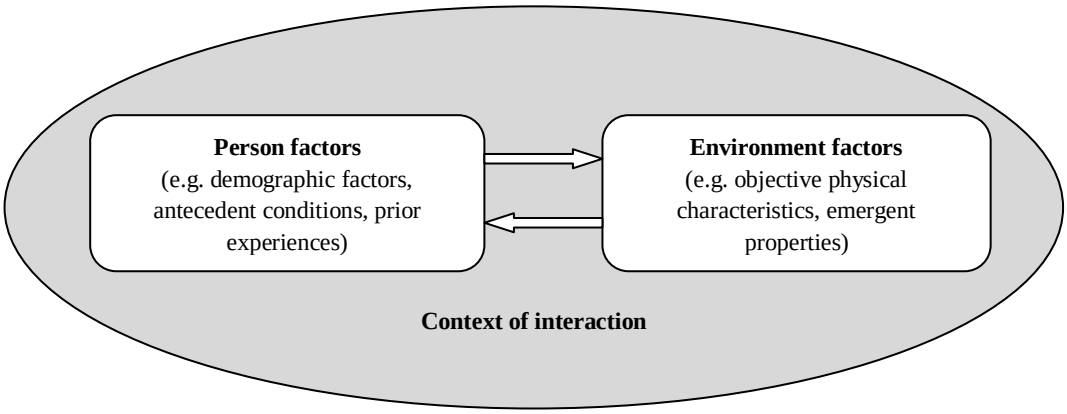


Figure 2.1: Framework for consideration of factors influencing restoration outcomes of person-environment interactions.

Given the focus of this study on the planning and design of restorative open space, the greatest part of this discussion will centre on the environmental factors influencing restoration benefits (section 2.4). It is, however, important that these be considered in relation to other key factors relating to the individual (section 2.5) and to the context of the person-environment interaction itself (section 2.6).

2.2 Theories of restorative environments

Environmental psychologists have been studying the psychological benefits of contact with nature since the late 1970s. This line of enquiry has since developed into the multi-disciplinary field of restorative environments research. This body of research focuses on the stress-relieving, concentration boosting, and mood enhancing benefits of contact with nature that have been demonstrated in a range of experimental and cross-sectional studies. Two theoretical frameworks were developed to explain the mechanisms by which these benefits arise, and these perspectives continue to underpin restorative environments research. These are:

- Stress recovery theory (SRT), also referred to as psycho-physiological stress reduction theory, stress reduction theory, or psycho-evolutionary theory; and
- Attention restoration theory (ART)

These are, for the most part, considered to be complementary rather than competing theories as they emphasise two distinct (yet potentially interacting) psychological processes, each of which is supported by empirical evidence (Kaplan 1995, Hartig et al. 2003, Hartig 2007).

2.2.1 Stress recovery

This theoretical perspective on restoration emphasises the stress-relieving effects of natural environments. Stress recovery has both a psychological dimension (reducing subjective feelings of stress and eliciting positive emotions) and a physiological dimension (recovery from the body's objective stress response). Much of the early experimental research testing the effects of single, discrete exposures to different environments on stress levels compared responses to viewing slides or videos of 'natural' versus 'urban' environments after exposure to a stressor. In this context, 'natural' is taken to mean scenes dominated by vegetation (which may or may not contain water), with 'urban' tending to refer to exclusively built environments lacking any visible vegetation. Given the ambiguity of both the terms 'natural' and 'urban' in the context of the design of (peri-)urban open space, this dichotomy adopted in the environmental psychology literature will instead be referred to in this chapter in terms of 'green' versus 'grey' environments. The results of these studies indicate that viewing a green environment promotes recovery from stress more effectively than viewing a grey one. This advantage of green over grey environments has been measured using objective indicators of stress like heart rate, blood pressure, muscle tension, skin

conductance, and brain wave patterns (Ulrich 1981, Ulrich et al. 1991, Parsons et al. 1998, Laumann et al. 2003). On the subjective level, exposure to green scenes is associated with greater increases in positive emotion and decreases in negative emotion (Ulrich 1979, Ulrich et al. 1991, van den Berg et al. 2003). These self-reported emotional responses are supported by evidence of differential activation of areas of the brain associated with positive and negative emotions when viewing rural and built scenes (Kim et al. 2010). Similar self-reported and objectively measured effects on physiological and emotional stress outcomes have also been demonstrated in response to immersive experiences in green/rural versus largely grey/urban environments in quasi-experimental field studies (Hartig et al. 2003, Morita et al. 2007, Park et al. 2010, 2011, Roe and Aspinall 2011a, Johansson et al. 2011, Aspinall et al. 2013). Furthermore, studies on the stress-reducing effects of longer exposures to natural environments suggest that these stress reduction benefits may also have profound effects on the immune system. A three day break in a forest environment, as opposed to a city sightseeing break of the same length, was found to have a significant positive impact on immune functioning which lasted for more than 30 days. The forest break also promoted levels of anti-cancer proteins in the blood and reduced subjects' adrenaline levels (Li 2010).

Further evidence for the stress-relieving benefits of nature can be seen in the meanings of greenspace and rural environments in the popular consciousness. Visiting forests/woodlands or other types of greenspace rank high amongst the strategies that people would recommend to a friend struggling to deal with stress (Grahn and Stigsdotter 2003, Hansmann et al. 2007) and stress relief is a common stated motivation for visiting greenspace (e.g. Hansmann et al. 2007, Schipperijn et al. 2010) . People also often develop strong emotional attachments to particular green (or blue) spaces. Green and waterside environments are more commonly reported as favourite places than indoor environments or urban streets and public spaces not dominated by nature (Korpela and Hartig 1996, Korpela and Ylén 2007, Korpela et al. 2008, 2009, 2010). The 'environmental self-regulation hypothesis' of place attachment proposes that the role that places play in individuals' attempts to regulate their emotions and mental states underlies the development of place identity (see e.g.Korpela and Ylén 2007, Korpela et al. 2008).

Ulrich suggested a functional-evolutionary basis to these stress-relieving effects (Ulrich 1986, 1993, Ulrich et al. 1991). Stress recovery theory argues that rapid-onset

emotional reactions are a critical part of the initial response to threats in the environment, mobilising the body's physiological systems and motivating 'fight or flight' behaviour. However, the costs of this stress response are high (strong negative emotions and energy-sapping physiological arousal), so there is a need for restoration to occur when the threat has passed. It is proposed that we evolved a propensity to respond both emotionally and physically in a strong positive way to favourable natural environments as an adaptive mechanism to allow fast and effective recovery from this stress response, and that modern humans retain this adaptation. The theory suggests that this unconscious 'prepared response' occurs automatically in natural environments and not built environments because of mankind's long evolutionary history in nature. By contrast, our history of living in permanent settlements is almost negligible on an evolutionary timescale**.**

From this perspective, environments 'elicit like-dislike feelings, which in turn motivate approach-avoidance behaviours appropriate to the observer's on-going well-being' (Ulrich 1986:32). This adaptive evolutionary explanation for responses to landscape perception is reflected in Wilson's 'biophilia hypothesis', which suggests that humans have an 'innate tendency to focus on life and lifelike processes' (Wilson 1984:1). Ulrich's development of the biophilia hypothesis argues that humans are effectively hard-wired to learn to respond rapidly and positively to non-threatening natural landscapes (a form of biophilia) and strongly negatively to potential natural threats like snakes and spiders or sources of danger in the landscape like steep cliffs (examples of biophobia) (Ulrich 1993).

The discussion of what makes a natural environment more or less restorative from the perspective of stress recovery theory draws on evolutionary theories of landscape aesthetics, notably habitat/prospect-refuge theory (Appleton 1975), and the savanna hypothesis (Orians 1980).

Appleton's prospect-refuge theory asserts that 'at both human and sub-human level the ability to see and the ability to hide are both important in calculating a creature's survival prospects' (Appleton 1975:73). It proposes that landscape preferences are based on the perception of three key environmental properties - prospect, refuge and hazard - that act as signs indicating whether an environment is favourable for survival i.e. whether it constitutes good human habitat or not. 'Prospect' refers to the opportunity to see out to the surrounding landscape - the visual access afforded by the environment and its openness. 'Refuge', on the other hand, refers to the opportunity to hide, to be

screened from view by vegetation or other landscape features. The final component of the theory - 'hazard' - is important in that it is the object of motivations to see or hide. To early humans the source of perceptions of hazard would likely be predators or members of rival communities (Appleton 1975).

The savanna hypothesis builds on observations of cross-cultural preferences towards savanna or parkland landscapes, characterised by grassland punctuated by large trees or small groups of trees (Balling and Falk 1982, Ulrich 1986, Falk and Balling 2010). It proposes that these aesthetic preferences relate to *Homo sapiens'* evolutionary origins in savannah landscapes. Many of the features that differentiated early humans from its forest-dwelling ancestors are hypothesised to be adaptations acquired because of a change of environment from forests to savanna ecosystems, and so, it is argued, environmental features associated with savanna landscapes should instinctively signal positive human habitat (Heerwagen and Orians 1993). Savannas offered many advantages to early humans - they were rich in herbivorous mammals to hunt, whilst also offering opportunities for prospect through their wide vistas, and refuge amongst their trees and rocky outcrops.

Both of the evolutionary aesthetic theories discussed above relate closely to the concept of 'affordances'. As described by Gibson 'the affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill' (Gibson 1979:127, in Chemero 2003). Heft (2010:18) defines affordances as 'perceptible properties of the environment that have functional significance for an individual'. Affordances can also usefully be considered as the opportunities for action that an environment offers, or its 'action possibilities' (Withagen et al. 2012). These are properties of the environment *in relation* to the individual, rather than referring solely to either the environment or its perceiver (Heft 2010, Withagen et al. 2012). From the functional-evolutionary perspective, landscapes carrying affordances for behaviour important for survival (e.g. drinking, eating, sheltering, moving easily, viewing, climbing and hiding), should be preferred across human cultures. Indeed, there is evidence of cross-cultural preferences for landscapes containing features that signal affordances in terms of current and future availability of resources such as safe drinking water and food, and for visual surveillance and security (Ulrich 1986, 1993, Heerwagen and Orians 1993). Empirical evidence on affordances that support restoration is considered later in this chapter.

2.2.2 Attention restoration

Attention Restoration Theory (Kaplan and Kaplan 1989, Kaplan 1995) explains the restorative benefits of nature to cognitive rather than psycho-physiological processes. From this theoretical perspective, accompanying improvements to mood and reduction in feelings of stress and anxiety may be linked to an overarching benefit to information processing capabilities (Kaplan 1995, Kaplan and Kaplan 2003).

ART rests of the idea that we have a finite capacity for focusing our attention, which becomes depleted with mental effort, causing a state of 'attentional fatigue' and a concomitant reduction in mental performance. It is argued that maintaining directed attention requires blocking out unwanted distractions from the environment, and for this to happen an inhibitory mechanism is needed. Exercising this mechanism uses energy and depletes attentional resources. When our ability to voluntarily direct attention is depleted, restoration through rest, sleep or relaxation in a supportive environment must occur before performance can rise again (Kaplan 1995). Natural environments are held to be particularly conducive to attention restoration, but effective restoration need not be confined to these. According to ART this state of attentional/mental fatigue has negative effects not just on performance on tasks requiring focus and concentration, but may also have deleterious effects on moods and behaviour, with irritability, frustration, impatience, depression, impulsivity and social irresponsibility implicated as consequences of attentional fatigue (Kaplan 1995, Kuo and Sullivan 2001, Kuo 2001, Kaplan and Kaplan 2003).

Experimental studies have provided evidence for the effects of discrete contacts with nature on attention and performance of tasks requiring concentration. When a state of attentional fatigue has been induced, adult subjects exposed to green rather than grey environments have been found to perform better on subsequent cognitive tests (Hartig et al. 1991, Hartig et al. 2003, Berto 2005). Studies of children diagnosed with attention deficit hyperactivity disorder (ADHD) have also found evidence of enhanced attention after activities in greenspace as opposed to built settings (Kuo and Taylor 2004, Taylor and Kuo 2009, 2011). The findings of experimental studies have, however, been somewhat mixed. Some studies, although finding trends indicative of a benefit, have found no statistically significant effects on attention (Bodin and Hartig 2003, van den Berg et al. 2003). This may reflect differences in the sensitivity of the various instruments used to measure attention, in the duration of environmental exposure in

different studies, or the absence or ineffectiveness of fatigue induction measures. There is, however, some evidence that viewing green environments can lead to a decline in *spatially selective* attention, which has been interpreted as a consequence of reducing physiological arousal (Laumann et al. 2003). Immediate effects of environment on different forms of attentiveness and potential interactions between stress recovery and attention restoration processes on the capacity to direct attention during and immediately following greenspace exposures of different durations are therefore not fully understood.

The Kaplans proposed four components that contribute to an environment's restorative potential in terms of recovering the capacity for directed attention - 'being away', 'fascination', 'extent' and 'compatibility' (Kaplan 1995). These components are described in box 2.1 below.

Box 2.1: ART's four components of restorative environments (Kaplan 1995, Hartig 2007)

1) *Fascination* – This describes surroundings which attract interest and draw the attention without any effort on the part of the viewer (involuntary attention). A distinction is made between 'hard' and 'soft' forms of fascination. Soft fascination, where involuntary attention is drawn in a manner that still allows room for self-reflection during the experience, is thought to be particularly important for attention restoration.

2) *Being away* – This relates to achieving a sense of psychological distance or escape from demands and drains on directed attention.

3) *Extent* – This construct refers to the scope of the environment in question. It is argued that for effective restoration the environment must be comprehensive enough to feel like a world to itself. 'It must provide enough to see, experience, and think about so that it takes up a substantial portion of the available room in one's head' (Kaplan, 1995:173).

4) *Compatibility* – This relates to the fit between the individual's purposes and inclinations for behaviour in the environment and the behaviour that the environment permits or demands. A compatible environment allows desired activities to be carried out with ease, and does not demand behaviour that feels uncomfortable or unnatural.

ART holds that natural environments often offer high levels of each of these components supportive of restoration, more so than most urban environments, and this is the reason for the patterns of variation in restoration between green and grey environments. Perception of high levels of these qualities has been linked to objectively measured restoration benefits, in terms of affect (emotion) (Hartig et al. 1997) cognitive performance (Berto 2005, Berto et al. 2010) and also stress (Chang et al. 2008).

2.3 Cumulative effects of restoration on health and wellbeing

A considerable portion of the restorative environments literature has investigated the potential cumulative effects of repeated exposures to green/blue space and rural environments on health and wellbeing in various contexts. Because this type of research focuses on the benefits of nature in everyday contexts (where the researcher has limited control of environmental conditions), most studies have used a cross-sectional research design to test for correlations between greenspace exposure and the outcomes of interest. These studies are, in some ways, of much greater practical value than the laboratory and field studies of the discrete effects of greenspace, particularly in terms of building an evidence base to inform planning and public health policy. Yet what these studies gain in external validity they lose in internal validity; they are susceptible to selection effects and confounding factors. Although these may be possible to control through statistical analysis, it is not always possible to infer causal directions in any relationships found. These limitations are particularly relevant when considering greenspace use. Firstly, it is very difficult to separate the potential effects of restoration from other potential benefits of use like increased physical activity and social interaction, as alluded to in the previous chapter. Secondly, wellbeing, stress levels and attentional functioning could each be argued to influence greenspace use rather than vice versa. For these reasons, some of the most persuasive evidence for cumulative *restorative* effects comes from studies focusing on visual access to greenspace through windows.

In most cases, apparent restoration benefits cannot be confidently attributed to either stress recovery or attention restoration alone. These two processes may operate concurrently and it is possible that they often interact. It has been argued that whilst prolonged stress may limit executive functioning[1] and reduce cognitive performance, at the same time chronic attentional fatigue may act as a cause of stress (Kaplan 1995). Nevertheless, in many cases researchers have speculated on the relative contribution of stress recovery and attention restoration to positive outcomes. Some have addressed this issue systematically by examining potential mediating effects of stress levels and attention capabilities (e.g. Kuo 2001, Kuo and Sullivan 2001).

[1] The term executive functioning refers to the ability to control cognitive processes necessary for complex goal-oriented activities such as planning, ordering, problem solving, blocking distraction, and applying self-discipline (Elliot 2003, Barkley, 2012).

There has been much interest in the restorative value of greenspace in institutional contexts, particularly in the design of healthcare settings, where the concept of 'healing gardens' has been influential (Stigsdotter and Grahn 2002, Hartig and Cooper Marcus 2006). This may be seen to stem from Ulrich's early study of hospital patients recovering from surgery, in which it was reported that patients made a quicker recovery and required less pain relief if they had window views of trees rather than brick walls (Ulrich 1984). Regarding other institutional contexts, one study found that prison inmates with rural window views use health care facilities less often than counterparts with built views (Moore 1981). An ecological study of a sample of American high schools found that greater prominence of trees and shrubs in window views from cafeterias and classrooms was associated with higher attainment in terms of standardised test scores, graduation rates and student intentions to progress to higher education, as well as lower levels of criminal behaviour, after controlling for various factors relating to the composition of the student body and age of school buildings (Matsuoka 2010). Tennessen and Cimprich (1995) demonstrate further evidence of cumulative benefits to performance in educational settings; they found that university students with more natural views from their dormitories exhibited a greater capacity to direct attention on a range of cognitive tests.

Much of the research on the potential cumulative restorative benefits of greenspace has, however, focused on residential environments. Kaplan's (2001) study on window views from the home found relationships between window view content and aspects of self-reported wellbeing; seeing gardens and flowers was positively associated with effective functioning, and seeing trees positively related to feelings of being at peace and negatively with states indicating mental fatigue. A high profile series of studies (Kuo et al. 1998, Kuo and Sullivan 2001, Kuo 2001, Taylor et al. 2002) was conducted in an area of public housing in Chicago, identified by the researchers as a natural experiment ideal for studying greenspace benefits. The neighbourhood comprised a number of architecturally identical high rise buildings with varying levels of landscaping in their immediate surrounds - some with none at all, others with small areas of grass and a few trees. Residents were randomly assigned to their homes, (negating any potential for self-selection bias) and had no role in the management of the greenspace. The population, considered to be at high risk of experiencing chronic mental fatigue due to high levels of deprivation, was described as 'strikingly homogeneous' in terms of income, education, life circumstances and opportunities (Kuo 2001:12). Residents of

the greener buildings reported fewer incidents of aggression and violence towards family members (Kuo and Sullivan 2001), and were coping more successfully with the pressures of poverty - they reported their problems as less severe and insurmountable than those in buildings lacking nearby nature, and were more proactive in pursuit of life goals (Kuo 2001). These relationships were mediated by participants' attentional functioning (rather than stress levels or social support), which suggests that the primary mechanism driving these effects was attention restoration.

Another study in this series addressed the effects of nearby nature on children, finding that greener views from the home were associated with greater self-discipline, though only in girls (Taylor et al. 2002). A previous study also demonstrated effects on children's cognitive functioning; differences in attentional functioning before and after moving home were associated with changes in the amount nature seen from windows and in the garden (Wells 2000). A more recent study found that the risk of babies being born with low birth weight was lower when the area around mothers' homes had greater tree canopy cover and access to greenspace (Donovan et al. 2011). The authors attribute this finding to reductions in stress, as stress during pregnancy is known to affect birth outcomes.

Overall, the research on cumulative restoration effects of nature point to wide ranging benefits to the wellbeing of both adults and children. Whilst the discussion here has been limited to examples from residential and institutional contexts, a number of studies have also explored cumulative effects in the context of the workplace. These studies are reviewed in detail in chapter 3.

2.4 What makes an environment restorative? - Environmental factors

The above studies on cumulative restoration outcomes, along with the wider epidemiological research on spatial relationships between greenspace availability and population health (see section 1.1.2) together provide a persuasive argument for the value of urban greenspace. Recent epidemiological research indicates that it is not only the provision or quantity of greenspace that matters for health and wellbeing, but also its quality (van Dillen et al. 2012, Francis et al. 2012). The following section discusses research that extends beyond the broad brush dichotomy of 'natural' versus 'urban' that characterises much of the restorative environments literature (Velarde et al. 2007, Jorgensen and Gobster 2010) to explore how the physical characteristics of

environments influence restoration. Studies aiming to build our understanding of what makes an environment restorative are of considerable practical value in developing evidence-based approaches to planning, designing and managing open spaces that maximise opportunities for restoration.

Many studies, rather than measuring restoration outcomes in response to different conditions, have quantified the perceived restorativeness of environments using participants' ratings of the likelihood of experiencing restoration, or scores on psychometric scales designed to measure restorative potential. A number of such scales have been developed, with the most widely used being the various versions of the Perceived Restorativeness Scale (PRS) (Hartig et al. 1997, Purcell et al. 2001, Berto 2005). The PRS measures perceptions of the four components of ART - fascination, being away, compatibility and extent, as does the ART-based Restorative Components Scale (RCS) (Laumann et al. 2001). Other scales such as the Short Revised Restoration Scale (SRRS) (Han 2003) and the Restoration Outcomes Scale (ROS) (Korpela et al. 2008) draw on both theories of attention restoration and stress recovery. These methods present an attractive option for researchers, particularly as they are less resource intensive than direct measurement of outcomes. They also allow individual scenes to be treated as sample units. This opens up the opportunity to analyse how levels of different qualities each relate to restorativeness, which has been useful for theory development.

2.4.1 Responses to different types of green and blue spaces

Several studies have used experimental designs to compare responses to a range of different landscape types, some focusing on comparisons between different types of urban, natural and mixed scenes (e.g. Purcell et al. 2001, Laumann et al. 2001) and others comparing wild land or rural landscape types (Han 2007, Vassiljev et al. 2007). Three broad landscape categories are highlighted here with respect to urban/periurban open spaces. These are: forests and woodland, parklands and grasslands, and blue space. Other landscape types highlighted in the literature include hills and mountains, which are also commonly rated as highly restorative (Laumann et al. 2001, Purcell et al. 2001, White et al. 2013c).

Forest and woodland

Forests and woodlands often feature highly amongst landscape types in terms of perceived restorativeness and preference (Peron et al. 1998, Laumann et al. 2001, Han 2007, Vassiljev et al. 2007), as well as restoration outcomes reported by users (White et al. 2013c). Visits to forests are associated with measured benefits to self-reported stress levels and mood states amongst both adults and children (Hansmann et al. 2007, Morita et al. 2007, Park et al. 2011, Roe and Aspinall 2011b), as well as physiological measures of stress like heart rate, blood pressure, cortisol and adrenaline levels and immune activity (Li 2010, Park et al. 2010, Tsunetsugu et al. 2010).

People commonly strongly associate forests and woodlands with relaxation and restoration. These have been reported as the most desired environment for relaxing and recovering from stress and mental fatigue (Grahn and Stigsdotter 2003, Hansmann et al. 2007) and feature highly in studies of favourite places (Korpela et al. 2010). In Japan, this popular association can be seen in the prevalence of the popular pastime 'shinrin-yoku' (forest walking or forest air bathing) for stress-management (Tsunetsugu et al. 2010). However, forests are not always therapeutic. They are often culturally associated with danger, and may be experienced as fearful places particularly by women and those of ethnic minorities (Burgess et al. 1988, Milligan and Bingley 2007, Skår 2010). In line with this consideration, Vassiljev et al. (2007) found that woodland featured amongst both the most and least restorative vegetation types studied.

Park and grasslands

Several studies have explored how responses to forests environments differ from parklands and grasslands, which are closer to the type of environment the savanna hypothesis suggests should be most restorative from an evolutionary standpoint. Field studies have demonstrated the restorative effects of park visits on self-reported moods (e.g. Hansmann et al. 2007, Johansson et al. 2011), supported by a recent study tracking changes in brainwave patterns in real time as a result of moving between city streets and an urban park (Aspinall et al. 2013). However when directly compared to woodland environments, grassland/savannah landscapes and parks have both been found lower in perceived restorativeness (Laumann et al. 2001, Han 2007). Likewise, recent analysis of a large-scale recreational survey in England found that users report urban parks and open spaces (and particularly playing fields and playgrounds) as having less of a restorative effect than (rural) forests and woodlands, even after controlling for the

activities performed (White et al. 2013c, cf. Hansmann et al. 2007). We might expect restorative potential to vary greatly between different parks and designed open spaces; whilst featureless parks dominated by grass are often perceived as bland and boring (Burgess et al. 1988), those with more to see and experience are likely to provide more in the way of fascination, contributing towards higher restorativeness.

Blue space

Coastal and waterside environments, or blue spaces, are another type of open space commonly associated with restoration and relaxation. People tend to rate the coast and inland water bodies like lakes as particularly high in restorative potential and preference, often exceeding all other landscape types (Peron et al. 1998, Purcell et al. 2001, Laumann et al. 2001, Korpela et al. 2010, White et al. 2013c). Recent cross-sectional and longitudinal epidemiological research has indicated that living closer to the coast is associated with better physical and mental health (Wheeler et al. 2012, White et al. 2013a), however the same pattern has not been found with respect to freshwater bodies (White et al. 2013b).

2.4.2 Open space features and restorative potential

Few studies have examined how particular features or components of designed open space may contribute to (or limit) restoration, however more evidence is available on preferences for certain features. The findings of these studies are briefly summarised below with respect to built features, trees and shrubs, grass, flowering plants, and water features.

Built features

Built features may, from the research on green vs. grey environments, be expected to limit the restorative potential of green and blue features, however this need not be the case, as some mixed built-natural environments are perceived as more restorative than other entirely green environments (Peron et al. 2002), and built features in window views do not necessarily detract from the cumulative benefits of green views (R. Kaplan 2001). In fact, built features like seating, paved paths and structures containing facilities can help to support multiple use so may enhance compatibility for a wider range of users.

Trees and shrubs

Studies that have differentiated between different vegetation features converge in support of the positive influence of trees. Trees are reported to contribute strongly to the perceived restorativeness of small urban parks (Nordh et al. 2009, Nordh et al. 2011) and to affective restoration in urban environments (Lohr and Pearson-Mims 2006). In addition, the presence of trees (and particularly mature trees) is a key influence on satisfaction with open spaces and the urban environment in general (Lohr et al. 2004, Sullivan and Lovell 2006, Kaplan 2007, Hur et al. 2010, Joye et al. 2010). In Matsuoka's (2010) study on the effects of vegetation types visible in school windows viewing trees and shrubs was positively associated with pupil attainment. Other studies have also reported positive associations between the presence of bushes and shrubs and the perceived restorative potential of urban open spaces, though their positive effect appears weaker than that of trees (Nordh et al. 2009, Nordh et al. 2011). Although studies of landscape types have reported mixed results in terms of the relative restorativeness of coniferous versus deciduous woodlands (see Han 2007, Vassiljev et al. 2007), studies of emotional responses and preferences towards different tree shapes indicate that trees with a spreading canopy are more conducive to restoration than rounded or conical shapes (Parsons and Daniel 2002, Lohr and Pearson-Mims 2006).

Grass

The evidence is somewhat more mixed with regards to the influence of grass. Large areas of mown lawn tend not to be highly valued, and may be negatively associated with wellbeing - school grounds with higher lawn footprints are associated with lower pupil attainment (Matsuoka 2010). However, the amount of grass cover visible has also been reported to positively predict perceived restorativeness in small urban parks (Nordh et al. 2009, Nordh et al. 2011). Studies on landscape aesthetics have generally, but not exclusively, found that smooth ground textures such as mown grass, which allow easy movement, are preferred to the rougher textures (Parsons and Daniel 2002, Kaplan 2007).

Flowering plants

The presence of cut flowers in hospitals has been associated with patients' recovery from surgery (Park and Mattson 2008), however there is less evidence for restorative benefits of flowers in outdoor environments where other types of vegetation are also present. In fact, in one study blossoming trees were found to raise heart rate and blood

pressure (Tsunetsugu et al. 2010), although this particular finding may be related to strong cultural associations in Japan where the study took place, since the 'sakura' (cherry blossom) season is accompanied by festivities. In other studies flowers have been found to relate neither to perceived restorativeness nor perceptions of danger, yet scenes containing flowers tend to be preferred over those without (Jorgensen et al. 2002, Nordh et al. 2009, Nordh et al. 2011).

Water features

Finally, a number of studies have demonstrated the power of water features to evoke positive emotions and perceptions of restorativeness as well as being a feature of preferred settings (see e.g. Ulrich 1986, White et al. 2010, Völker and Kistemann 2011). However, in the context of urban parks water may bear less influence on the perceived likelihood of restoration than structural vegetation like trees, bushes and grass (Nordh et al. 2011). There is limited evidence on how different types of water features influence restorativeness, however Nordh et al. (2011) found no differences between responses to mirror ponds and small fountains.

2.4.3 The spatial configuration of restorative greenspaces

The experience of an environment depends not just on the perception of particular physical features, but also their spatial qualities and relationship to one another. It is outside the scope of this study to provide an exhaustive review of the evidence on emergent properties of environments in landscape perception research. Therefore this section focuses on aspects of the spatial configuration of open spaces that appear most salient in terms of the affordances that may support restoration processes.

Prospect, refuge and escape

The evidence from restorative environments and landscape aesthetics literature suggests that the related qualities of vegetation density, enclosure, and openness play an important role in determining restorativeness. These qualities strongly influence affordances for prospect (visual access), refuge (hiding) and escape (ease of movement) each of which can determine feelings of security (Appleton 1975, Fisher and Nasar 1992). Feeling safe is, by definition, a necessary condition for restoration to take place, and therefore spatial configurations that limit an individual's perceptions of safety will also limit restorativeness for that person. The literature shows a mixed picture in terms of the influence of vegetation density, enclosure, and openness (which may be

understood as a function of both vegetation density and enclosure). Several studies have found more open and less enclosed environments to be perceived as safer (Herzog and Chernick 2000, Jorgensen et al. 2002, Andrews and Gatersleben 2010) and more restorative (Galindo and Hidalgo 2005, Han 2007, Gatersleben and Andrews 2013). A recent study by Gatersleben and Andrews (2013) explored differences in restoration outcomes in high prospect-low refuge versus low prospect-high refuge environments, and found the high prospect-low refuge condition to be significantly more restorative in terms of objective effects on attention and heart rate as well as subjective affective outcomes. It should be noted, however, that the range of variation in prospect and refuge in this study was limited; the country park setting meant that the high prospect-low refuge condition was not what might be typically considered as a very open environment, and still afforded a certain level of refuge.

Other studies have, conversely, found more open environments to be perceived as less restorative when controlling for perceived ease of movement (Herzog et al. 2003), and dense tree canopies to be associated with reduced psycho-physiological stress (Lohr and Pearson-Mims 2006). Grahn and Stigsdotter (2010) have explored preferences towards perceived sensory dimensions of open spaces and found that refuge tends to be favoured over prospect. Preferences towards prospect and refuge appear to be moderated by an individual's state of mind. Whereas states of anger increase preferences for prospect, states of tension, anxiety and fatigue and higher stress levels strengthen preferences for refuge (Mealey and Theis 1995, Grahn and Stigsdotter 2010, Peschardt and Stigsdotter 2013). Studies in the workplace context have found that employees tend to prefer and be more disposed to use open spaces that offer refuge and certain levels of enclosure (Kaplan 2007, Lottrup et al. 2012).

Overall, it seems likely that in designing restorative greenspaces, there is a balance to be struck in terms of vegetation density, enclosure and openness. Very dense vegetation and enclosed spaces afford little prospect, may conceal threats and limit escape, and so may evoke feelings of insecurity. On the other hand, very open environments are high in prospect and (depending on the smoothness of the ground vegetation) may also offer plenty opportunity for escape, but may at the same time afford little refuge. Refuge appears to be particularly important for those in need of restoration, but at the same time there appears to be a need for 'enough' prospect and escape to support perceptions of safety. This interpretation is in line with functional-evolutionary explanations of why

preferred landscapes tend to be of intermediate density, and offer both prospect *and* refuge (Appleton 1975, Ulrich 1986).

Coherence, complexity, legibility and mystery

Spatial qualities also influence how easily we understand and navigate in an environment and the opportunities it offers for exploration. Kaplan and Kaplan's (1989) information processing theory of landscape aesthetics argues the importance of four environmental properties in determining landscape preferences: coherence, complexity, legibility and mystery. Although the relationship of these qualities to restoration potential has not been comprehensively explored there are some indications of their relevance in this context.

Complexity has received the greatest attention with respect to restorative environments, with several studies suggesting that more complex environments are more restorative (Han 2007, Pazhouhanfar et al. 2012) and tend to be seen as more attractive (van den Berg et al. 1998, Parsons and Daniel 2002, Home et al. 2010). This makes sense in terms of both attention restoration and stress recovery theories - relatively complex and diverse environments are likely to provide more to draw involuntary attention (fascination) and may be rich in different resources. However, landscape preference studies indicate that preferred environments are not uniformly high in complexity, rather a moderate to high level is favoured, since an overly complex environment lacking a focal point may lack order and coherence (Ulrich 1986). That an environment is sufficiently coherent and ordered is arguably an important facet of its potential for attention restoration, particularly as part of the construct of 'extent' (Hartig et al. 1997, Hartig 2007). Whilst perceived levels of coherence have been found to be positively related to perceived restorativeness (Pazhouhanfar et al. 2012), other studies also suggest that coherence is not a strong influence on restoration (Hartig et al. 1997, Purcell et al. 2001). Again this may point to a need for balance - preferred environments are "complex yet comprehensible" (Parsons and Daniel 2002:47) so it may be that for greenspaces to promote restoration they should be fairly complex yet coherent enough to be easily grasped and understood.

Legibility also relates to coherence, in that both these constructs relate to how we make sense of an environment. Coherence relates to making sense of the visual plane (in the sense of a two-dimensional image), whereas legibility relates to our understanding of how we can move and navigate through the three-dimensional landscape (Kaplan and

Kaplan 1989). Few studies have explicitly examined how legibility relates to restorativeness. Although legibility has been found to be unrelated to restorativeness in one study (Pazhouhanfar et al. 2012), others indicate that ease of movement and accessibility (discussed above in terms of affordances for escape) is an important feature of restorative environments (Staats et al. 1997, Herzog et al. 2003, Vassiljev et al. 2007). The final of the four constructs, mystery, also relates to exploration of the three-dimensional landscape. An environment has mystery if it seems to invite you in with the promise that there is more to see and explore (Kaplan and Kaplan 1989). Studies indicate positive relationships between mystery and ratings of preference and scenic beauty (Ulrich 1986, van den Berg et al. 1998), and also perceived restorative potential (Pazhouhanfar et al. 2012).

2.4.4 Ecological integrity and human influence

Open space planning and management has shifted its attention from individual green spaces to multifunctional green infrastructure and strategic green networks operating at the regional scale. Research and policy have increasingly advocated the ecosystem approach - defined by the UN Convention on Biological Diversity as 'a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way' (CBD 2004). Central to the ecosystem approach is the concept of ecosystem services - 'the benefits humans obtain from ecosystems' (Millennium Ecosystem Assessment 2005); this provides a co-ordinated framework for understanding the environmental, social and economic values of ecosystems. Within this agenda, the restorative functions of open space are only one of the wide range of ecosystem services that multi-functional green infrastructure should seek to deliver. This has led researchers to question how the restorative potential of greenspaces relates to their ecological functioning, in an effort to reconcile human health and ecosystem health objectives in design and management (Jorgensen and Gobster 2010).

Biodiversity, as well as being an indicator of ecosystem health, appears to be an important factor in humans' selection of habitat - several studies have indicated associations between biodiversity and human population density at various scales (Cincotta et al. 2000, Fjeldså 2007). Biodiversity has also been found to positively predict the wellbeing benefits experienced by park users (Fuller et al. 2007). However, it seems that this relationship may rely on users being able to judge biodiversity levels fairly accurately. Whilst in the latter study users' perceptions of biodiversity were in

agreement with objective measures of species richness, a recent study using similar methods (conducted in largely semi-natural waterside green spaces in the same city) found that users' perceptions of biodiversity did not match actual biodiversity levels in these more ecologically varied sites (Dallimer et al. 2012). Despite this, ratings of perceived biodiversity were significantly associated with the wellbeing outcomes. Others have previously found aesthetic preferences to be positively related to perceived levels of biodiversity (van den Berg et al. 1998, Lindemann-Matthies et al. 2010). Grahn and Stigsdotter (2010) likewise found that individuals suffering from stress display stronger preferences towards greenspaces that have the perceived quality of being rich in species. These findings together strongly suggest that improving biodiversity can promote the restorative benefits of greenspaces, but perhaps only if our perceptions of the diversity present match reality. This creates a problem. If we are not necessarily accurate in our perceptions there are limitations to the extent to which conservation and wellbeing objectives are mutually supportive, especially if our perceptions are particularly likely to be inaccurate in biologically complex environments (Dallimer et al. 2012).

Related to these considerations of biodiversity and ecosystem functioning are questions about how restoration potential relates to human influence on the landscape. Attention Restoration Theory originally grew out of observations of wellbeing benefits from wilderness experiences (Kaplan and Kaplan 1989). Theoretical development on the sensory dimensions important for stress reduction has found that under stress people tend to prefer greenspaces with the perceived quality of 'nature on its own terms' (Grahn and Stigsdotter 2010, Peschardt and Stigsdotter 2013). There is also evidence to suggest that designed greenspaces like parks are less restorative than semi-natural rural greenspaces (Korpela et al. 2010, White et al. 2013c). We might therefore question whether human impact is negatively related to restoration potential. However, whilst nature left to its own devices can be a richly fascinating and complex array, it can also be messy and potentially unnerving. An ecosystem in an advanced state of succession may, to the observer, lack coherence and legibility, and limit prospect and escape. Research on landscape aesthetics indicates that people often prefer a balance between wildness and visible human influence; preferred landscapes tend to be 'comparatively ordered, 'civilised' assemblages of natural elements; most are not wild in terms of conveying a sense that human influences are absent' (Ulrich 1986:32). In the context of urban fringe business sites Hands and Brown reported that employees preferred 'an enhanced nature that was more colourful, more deliberate, and less messy than the

natural indigenous community... employees expressed a desire for their site to look *natural, but not too natural*' (Hands and Brown 2002:69, emphasis added). Human influence can be overt, as in the case of regimented planting and hardscaping, or the presence of litter in an environment, or it can be more subtle. Land management practices strongly shape landscapes like heather moorland and managed woodlands, without necessarily removing their quality of wildness. There are strong indications that the presence of litter limits restorative benefits (Reichhardt and Arnberger 2010, Dallimer et al. 2012) but less is understood about the consequences of design. Whilst people may not favour straight lines and hard edges (Home et al. 2010) and sometimes prefer design options that appear less cultivated or artificial (e.g. van den Berg et al. 1998, Ode et al. 2009) at the same time more manicured settings are often preferred to wilder settings that may appear unkempt (e.g. Hands and Brown 2002, Reichhardt and Arnberger 2010, Home et al. 2010). It has been suggested that preferences for wild versus tamed greenspace may depend on tradeoffs between understanding environments on the one hand and exploring them on the other (van den Berg and van Winsum-Westra 2010). Whilst neat and tidy spaces may be more coherent and legible, more naturalistic settings are argued to offer more in the way of exploration and arguably fascination, so in light of restoration theory it seems a balance is desirable. The appropriateness of different design treatments is also likely to be highly context-specific - Jorgensen et al. (2002) found that affective responses to different types of woodland understory and edges ranging from manicured to more naturalistic depended on the level of enclosure created by the vegetation. At greater levels of enclosure (less prospect, more refuge) dense naturalistic understory vegetation was perceived as less safe, however with little enclosure denser ground vegetation may in fact promote perceptions of safety.

The inclusion of features that can signal human intent, such as large rocks and human artefacts like bird boxes and interpretive signage, can act as 'cues to care' that enhance preference of naturalistic designs (Hands and Brown 2002). Human influence that signals that an environment is cared for can enhance feelings of safety and security, which may be particularly important in urban settings (Burgess et al. 1988, Herzog and Chernick 2000). Woodland management practices appear to be particularly relevant to restorative potential. Studies have indicated that managed woodlands are both preferred and more restorative than wild untended woods (Ulrich 1986, Vassiljev et al. 2007, Martens et al. 2011). As well as leaving visible cues to care, woodland management practices such as selective thinning. trail maintenance and management of invasive

species can enhance affordances for prospect and escape, as well as encouraging a more biodiverse and fascinating understory and maintaining a variety of ecological niches for wildlife. It is therefore likely that somewhat naturalistic urban open spaces that are sensitively managed and contain cues to care - those that are 'natural but not too natural' - are most likely to support restoration for the majority of users.

2.5 Who benefits (most)? - Individual differences in restoration

The restorative benefits of greenspace depend not only the qualities of the environment itself, but can also vary greatly between individuals. This section briefly outlines what is known about how person-centred factors - differences between different individuals and groups - influence the extent to which a person-environment interaction results in restoration outcomes. Relatively few studies have examined factors accounting for differences between individuals in the restorative benefits they derive from exposure to a particular green environment - this is therefore an area in which further study would be valuable.

2.5.1 Need for restoration

The single most influential person-centred factor accounting for variation in restorative benefits appears to be the individual's state of mind and their need for restoration. Restorative environments research has overwhelmingly found that those experiencing high stress levels, mental fatigue, poor mental health or behavioural problems appear to benefit the most from contact with green environments and are more strongly drawn to these settings (Staats et al. 2003, van den Berg et al. 2003, Hansmann et al. 2007, Morita et al. 2007, Korpela et al. 2008, Ottosson and Grahn 2008, Roe and Aspinall 2011a, 2011b). The wellbeing benefits of restorative greenspaces are therefore greater when there is greater potential for improvement to wellbeing and cognitive functioning.

This may help to explain patterns that indicate that individuals living in deprived areas benefit the most from access to green and blue spaces in terms of health and wellbeing, highlighting the potential role of open space provision in tackling socio-economic health inequalities (e.g. de Vries et al. 2003, Mitchell and Popham 2008, Maas et al. 2009b, Wheeler et al. 2012).

2.5.2 Demographic factors

Several epidemiological studies have found gender interactions in relationships between greenspace and health, with higher levels of greenspace associated with lower mortality

rates and lower stress amongst men only (Richardson and Mitchell 2010, Mitchell 2013). The reasons for this are not clear but are likely to be related to differences in use of greenspace by men and women (men tend to be more frequent users), and may also relate to differences between men and women in perceptions of safety in urban open spaces (Richardson and Mitchell 2010). Having said this, other studies have found living in greener areas to have a beneficial effect for women's stress levels but not men's (Roe et al. 2013). Studies examining the effects of actual use of greenspace provide little support for systematic gender effects in wellbeing benefits (e.g. Hartig et al. 2003, Grahn and Stigsdotter 2003, Korpela et al. 2008, White et al. 2013c). Despite this, women may be more likely to report stress relief as a motivation for greenspace use (Schipperijn et al. 2010).

Age may influence restoration outcomes in greenspace. Berto (2007) compared the perceived restorativeness ratings of greenspace and built environments made by groups of elderly, young adult and adolescent subjects. Although each group rated the green environments as more restorative, older people perceived them to have higher restorative potential than young adults and adolescents did, whereas young people found city environments more restorative than older people did. Likewise, the recent study by White et al. (2013c) found that the youngest respondents found visits to nature significantly less restorative than middle aged and older respondents. Other research also suggests that for middle-aged and particularly older people, meanings associated with place attachment and continuity with the past form a particularly important dimension of the experience of urban woodlands (Jorgensen and Anthopoulou 2007). However, in a study by Schipperijn et al. (2010) respondents over retirement age were less likely to report visiting greenspace for stress relief than both middle-aged and young adult respondents. Although the findings of these studies are somewhat mixed, overall indications are that although individuals of all ages associate green environments with restoration, middle-aged and older adults may be particularly likely to experience restorative benefits from visits to greenspace. Such differences between age groups may relate to stress levels and resultant needs for restoration.

2.5.3 Childhood experiences and nature connectedness

Childhood experiences of nature have been shown to positively influence people's likelihood of visiting greenspace and participation in nature-based activities as an adult, their willingness to visit greenspace alone, and the self-reported restorative effects of visits (Bixler et al. 2002, Korpela et al. 2008, Ward Thompson et al. 2008, Asah et al.

2011, Ward Thompson 2013). Familiarity may be a factor in this relationship, as familiarity with a landscape type has been associated with more positive evaluations (Balling and Falk 1982, Dearden 1984) and higher ratings of restorativeness (Purcell et al. 2001).

The relationship between childhood experiences of nature and restoration outcomes points towards the importance of personal history and relationship to the natural world. An emerging strand of restorative environments research focusing on connectedness to nature (also discussed in terms of nature relatedness, nature orientedness and environmental identity) indicates that the extent to which individuals feel personally connected to nature may influence restoration outcomes in greenspace, however the complex relationships between nature connectedness, use of greenspace and wellbeing are complex and not yet fully understood.

Nature orientedness has been found to be positively associated with the strength of restoration experiences in green favourite places (Korpela et al. 2008). Those who have a strong emotional connection to nature are also more likely to believe that engaging with natural environments helps them with stress management (Hinds and Sparks 2008), and are more likely to report restoration as a motive for using greenspace (Roderer and Cervinka 2011). However, connectedness to nature has not been found to influence ratings of perceived restorativeness with regards to outdoor versus indoor environments (Cervinka and Roderer 2011). Connectedness to nature and restorative experiences may be mutually reinforcing. Those with strong connections to nature tend to be strongly motivated to spend time in greenspace and therefore may be more likely to visit on a regular basis (Hands and Brown 2002, Hinds and Sparks 2008, Cervinka and Roderer 2011). Regular restorative experiences (which may be strengthened by the emotional connection to nature) may in turn reinforce this connection to nature - studies show that childhood experiences of nature and greenspace use levels in the more recent past are both positively associated with adults' connectedness to nature (Kals et al. 1999, Hinds and Sparks 2008).

2.6 Contextual factors

To understand the key factors of the person-environment interaction that influence restorative benefits of greenspace it is necessary not only to consider those factors relating to the person or individual (presented above in 2.5) and to the environment in

question (discussed in 2.4), but also factors relating to the context of the interaction itself. This section briefly outlines these factors.

2.6.1 Viewing vs. immersive experience

The restorative environments literature demonstrates that both window views and use of greenspace can result in restoration and benefits to wellbeing. However there is a fundamental difference between viewing an environment at a remove (whether through a window or in photographs) and an immersive engagement with it. Evaluations of perceived restorativeness made in situ have not differed significantly from ratings from photographs and videos of the same environments, however this does not mean that the actual restoration experienced is similar regardless of whether the environment is viewed from indoors or experienced directly (Hartig et al. 1997). Immersive experiences allow the perception of a wider range of sensory stimuli, yet the sounds, smells and physical sensations of outdoor green environments have often been overlooked in the research. Of these sensory dimensions, the sounds heard in greenspace have received the greatest attention. Soundscape research has shown that auditory stimuli can influence restoration - natural sounds like bird song and running water have a positive effect whereas traffic noise negatively impact on tranquillity and restorative potential (e.g. Irvine et al. 2009, Alvarsson et al. 2010, Watts et al. 2013). The smells of the forest are thought to play a significant role in the stress reducing benefits of shinrin-yoku (forest walking) in Japan - essential oils and other compounds present in wood have been shown to have a restorative effect of their own (Li 2010, Tsunetsugu et al. 2010).

Outdoor experience of landscapes also incorporates other embodied experiences relating to thermal considerations, weather and wind etc. which may influence psychological responses. There is a clear gap in the research on the impact of climate and weather on restoration. Motion is also known to influence responses to landscapes - preferences differ between static and dynamic visualisations of environments (Heft and Nasar 2000) and the speed at which the individual moves through the landscape can also influence preferences (Reichhardt and Arnberger 2010). Heft (2010) argues that 'qualities that arise from engaging the environment are vital to the affective experience of landscape' - the 'spectator stance' and the 'active perceiver stance' represent very different modes of environmental experience (Heft 2010:26). Despite this, little is known about the relative utility of viewing as opposed to using a particular green environment with respect to restoration outcomes.

2.6.2 Social context of greenspace use

More is known about how the social context of visits to greenspace influence restoration, however the relationship appears to be complex. Staats and Hartig (2004:209) found that visiting greenspace with others may either limit or promote restoration, depending on the context; concluding that 'company enables restoration by providing safety, but when safety is not a concern, restoration is enhanced by the absence of company'. This is supported by research on restoration in favourite places - controlling for feelings of security, visiting favourite places alone is associated with stronger self-reported restoration outcomes than visiting with company (Korpela et al. 2008). Similarly, in terms of the presence of other users, the research suggests that stress and mental fatigue are associated with preferences for low levels of social activity and less social stimulation from the environment (Staats and Hartig 2004, Grahn and Stigsdotter 2010). However, in the context of urban greenspace, the presence of a small number of other users may be preferred to solitude, most likely because users may feel more vulnerable when there are no others nearby (Nordh et al. 2011). The speed at which other users are moving may also impact on restoration experiences - fast moving cyclists and pedestrians are negatively evaluated by recreational trail users (Reichhardt and Arnberger 2010). This could be because these fast moving users are perceived as a threat to safety, or because their pace disrupts quiet contemplation and relaxation.

2.6.3 Length of time spent in a restorative environment

Several studies suggest that the longer the duration of a visit to greenspace, the greater the restoration outcomes reported (e.g. Hansmann et al. 2007, Korpela et al. 2008, White et al. 2013c). However, a meta-analysis of the dose-response relationships between the duration of green exercise trials and improvements to self-esteem and mood found that the greatest improvements from baseline came from short exposures of around five minutes (Barton and Pretty 2010).

The onset of psycho-physiological stress reduction occurs quickly; significant reductions have been found within 4-7 minutes (Ulrich et al. 1991). Attention restoration, on the other hand, appears to be a slower acting process. Significant effects on attention have not consistently emerged after 7-20 minutes but have tended to appear after longer periods of 30-50 minutes, and unlike the physiological effects of stress recovery, these attentional benefits persist after the period of environmental exposure (Hartig et al. 2003, Hartig 2007). Barton and Pretty's (2010) analysis indicates that

benefits to mood may peak fairly early in an environmental encounter, be followed by a period of diminishing returns as time in the environment progresses, and then climb gradually again from around one hour onwards. This absence of a traditional dose-response curve to affective restoration in greenspace may well stem from the differential timescales of stress recovery and attention restoration processes. It may be that the immediate effects of stress recovery cause the initial peak in mood, with the mood benefits of attention restoration following after a longer period of time in a restorative environment.

2.6.4 Weather and season

As noted previously in section 2.6.1, the impact of weather and climate conditions on the restorative benefits of greenspace remains under-researched. Cooler summer temperatures have been linked to increased rates of antidepressant prescription and it has been suggested that this may be due to weather and climate conditions constraining restorative outdoor activities (Hartig et al. 2007). However, although weather is a clear influence on greenspace use, it is not clear whether different weather conditions during use have a systematic effect on restoration outcomes. Weather has been considered as a potential source of variation in the design of experimental studies, yet the author is unaware of any experimental research actually attempting to measure the impact of weather conditions on restoration outcomes.

Similarly, seasonal variations in environmental conditions are under-researched with respect to restoration. One study in a rural setting found that ratings of perceived restorativeness varied between summer and winter for several vegetation types; in particular woodland environments tended to score higher in winter than summer, and more open environments higher in summer than winter (Vassiljev et al. 2007). Winter dieback of annual plant species may result in less complexity in open grassland habitats, yet in woodlands it results in a smoother ground cover which may be beneficial, especially in combination with enhanced visual access resulting from deciduous tree and shrub species losing their leaves (Vassiljev et al. 2007). Further research on the impacts of season and weather, both separately and in interaction, may improve our understanding of how to design greenspaces that are supportive of restoration in different conditions throughout the year.

2.7 Conclusions

This chapter has set out the primary theoretical framework guiding the present research project. Empirical research demonstrates the positive effects of spending time in greenspace on stress levels and coping, cognitive functioning, moods and self-esteem, with two leading theories - attention restoration theory and stress recovery - thought to explain these restorative effects.

Research on the environmental characteristics associated with effective restoration provides evidence on what types and configurations of greenspace are (most) restorative. Taken together, these studies indicate that structural vegetation - ground cover (e.g. in the form of grass), mid-level vegetation such as shrubs, and the vertical structure provided by trees - along with the presence of water, provides affordances that support restoration processes. Trees appear to be particularly strongly associated with restoration, and are highly valued both in greenspaces and in urban streets. Perhaps even more important than content is the structure and configuration of vegetation as this affects environmental affordances for prospect, refuge and escape, as well as the degree of fascination that it offers (related to complexity and mystery) and the ease at which we can comprehend the environment itself (coherence and legibility).

The literature review highlights both common ground and tensions between the promotion of ecosystem health and restoration. Hands and Brown (2002:69) succinctly present the main tension in this regard:

> *'It seems that although people have a visual preference for natural over built areas, what people perceive as 'natural' is often quite different in appearance from naturalized areas that are high in ecological function. In fact, the general public often disapproves of the appearance of areas that are high in ecological function.'*

Although semi-natural and naturalistic designed greenspace may be high in restorative potential, it may equally be limited in potential if it is overly complex, or perceived as unkempt and/or unsafe. It is important, however, to make a distinction between lack of human influence and ecological functioning, since sensitive habitat management can actually improve biodiversity and ecosystem health, whilst also potentially promoting restorativeness. Recent research indicates that greenspace rich in biodiversity may promote greater restoration benefits, but this effect appears to be mediated by our

subjective perceptions of the biodiversity present - the accuracy of which may depend on the extent of the individual's ecological knowledge (Dallimer et al. 2012).

The research exploring characteristics of restorative green environments strongly indicates the existence of a number of what might be considered as 'goldilocks factors'. These are properties which are optimal for restoration when they are present at intermediate levels - neither too low nor too high, but just right. It appears that the most restorative environments have neither low nor very high levels of complexity, coherence, prospect and refuge. Likewise, it seems that (particularly in urban greenspace) there is a fine balance in the effects of visible signs of human influence on restoration benefits, which may relate strongly to how design and management interact with these other factors in creating restorative as opposed to scary places. These goldilocks factors have implications for the methodological approaches used to study the impact of vegetation complexity and density, enclosure and openness on restorativeness. Future research would do well to consider the likelihood of non-linear relationships, rather than exclusively focusing on comparisons of low vs. high levels of these properties or testing for linear relationships, as has tended to be the case in previous research.

Whilst focusing heavily on the physical attributes of restorative environments this chapter has also highlighted the main individual-level factors that influence the restoration benefits experienced by a particular person at any given time. The individual's need for restoration - their antecedent levels of stress and/or mental fatigue and overall mental health - appear to be the most salient person-related factors. Those more in need of restoration, experiencing a deficit in their psychological resources, benefit the most from time in greenspace. It also appears that individuals' affinity or connectedness to nature may impact on, and in turn be moulded by, restorative experiences in childhood and later life. Demographic factors appear to be less significant when considered separately from these other variables - gender effects are inconsistent and are likely related to use levels, and potentially differences in restoration needs as is likely the case with the effects of socio-economic deprivation on the wellbeing benefits gained from greenspace.

The research reviewed in this chapter also demonstrates that the context of the person-environment interaction with greenspace can significantly influence its outcomes. Relatively little is known about the restorative effects of window views differ from

those experienced from active outdoor engagement with the same environment. It seems likely, however that differences exist and may be particularly determined by extra-visual sensory stimuli and the very act of moving through the environment. Whether people experience greenspace alone or in the presence of others may also influence restoration in different ways. Overall, it seems that as long as the individual feels safe, the greatest benefits are achieved when alone. Also, the duration of a visit can influence the benefits experienced. Spending just five minutes in greenspace should be enough to provide some stress-relief and gain a boost in mood, but longer stays have greater potential to enhance the benefits through attention restoration in addition to stress recovery. Finally, it seems intuitive that exogenous factors like weather, climate, and season fundamentally affect the experience of greenspace and therefore restoration processes. Seasonal changes to vegetation may be considered in light of their effects on the spatial properties of the environment. Little is known, however, about the impacts of weather and temperature on restoration outcomes in practice, and this is an area which certainly warrants further research.

Chapter 3: Nature, greenspace and the workplace

3.1 Introduction

This chapter gives an overview of greenspace research relating specifically to the workplace context. Emphasis is placed here on the role that greenspace plays for knowledge-sector workers. Given the attentional demands of knowledge-sector work, this group may potentially benefit the most from views and use of greenspace during the working day through opportunities for attention restoration. This chapter firstly reviews research on the wellbeing and related benefits of contact with nature at the workplace (section 3.2), then goes on to discuss the existing literature on employees' engagement with greenspace during the working day (section 3.3).

3.2 Benefits of exposure to greenspace and nature at the workplace

There has been relatively little research into the potential benefits of restorative experiences in the context of working environments. This is perhaps surprising considering that many people spend more of their waking hours at work than at home, and that many of the daily activities that cause stress or require sustained attention and focus (leading to a need for restoration) occur at work. In addition, considering the problem from the Scottish context, our latitude means that winter days are short and the only opportunity a 9-to-5 worker may get to interact with outdoor environments during daylight hours on weekdays is at their workplace. Stress, mental fatigue and overall wellbeing also have a potentially crucial impact on productivity as they can impact on both absence rates due to ill-health and on individuals' performance at work (Harter et al. 2003, Donald et al. 2005, CBI 2011). This concern is particularly salient for the knowledge-based industries that dominate in the type of commercial developments this study focuses on, since human capital is a primary driver of such businesses' productivity (de la Fuente and Ciccone 2003) and has also been seen to promote innovation (Dakhli and De Clercq 2004) . The term human capital refers to education, skills and knowledge as a resource that delivers economic returns to individuals, organisations or society (Becker 1962, de la Fuente and Ciccone 2003). There is a clear conceptual linkage between psychological wellbeing and individuals' ability to effectively apply their skills, knowledge, and creativity in their work. As such, investment in human capital need not be restricted to education and training but also to promoting employee health and wellbeing.

3.2.1 Views of greenspace and employee wellbeing

The majority of the research addressing the links between wellbeing and greenspace in the workplace context has focused on window views of nature. Much of the research has explored the cumulative impacts of view of greenspace on health, wellbeing and job outcomes, employing either cross-sectional surveys or quasi-experimental designs. Others have explored discrete restoration experiences at work using experimental designs. As previously touched on in section 2.3, cross-sectional and experimental designs have their relative advantages and disadvantages. Whilst cross-sectional designs are high in external validity, experimental designs are high in internal validity and therefore valuable for exploring causal relationships between green window views and wellbeing outcomes.

Cumulative benefits of views of greenspace at work

A range of different wellbeing and job outcomes have been investigated with respect to window view characteristics. As well as measuring different outcomes, these studies have also defined their measures of greenspace views differently. Some have used binary variables indicating presence or absence of nature in views (Kaplan 1993), or classification of views as either urban or natural (Aries et al. 2010), or specifically focused on whether a certain type of greenspace e.g. forest (Shin 2007) or garden (Stigsdotter 2004) can be seen in views or not. Other studies have represented views of greenspace using self-reported number of natural features present (Kaplan 1993), or researcher assessments e.g. of percentage of view made up by natural elements (Leather et al. 1998) or low, medium or high levels of naturalness (Beute et al. 2011). The wellbeing outcomes empirically associated with these various measures of greenspace views are discussed here in terms of a) general health, b) mental wellbeing, and c) job satisfaction. Kaplan (1993) attributes these apparent cumulative benefits of green window views to 'micro-restorative' experiences. It is argued that although instances of viewing nature through workplace window views may be very brief, short glances lasting perhaps only a few seconds may provide employees with micro-restorative benefits which have a significant cumulative impact on wellbeing and job outcomes.

Kaplan (1993) investigated the effects of natural features such as vegetation and water in the window views of a population of desk workers in the United States. Those who reported having natural features in their view experienced significantly fewer health problems or ailments in the six months prior to the survey. In a separate study looking

at the number of different natural features present rather than presence or absence of nature, those with a greater number of natural view features reported significantly higher satisfaction with the view. This in turn related to higher ratings of general health. There is therefore considerable scope for window views to influence levels of absenteeism due to ill health, which could translate to economic savings for organisations. In the UK staff absence costs employers an average of £673-£760 annually per employee (CIPD 2011, CBI 2011), so, over the course of a building's lifetime, providing restorative window views could potentially mean significant economic savings. Ill health does not only have economic costs when staff are absent but also on individuals' productivity when they do present for work when unwell. Almost 9 out of 10 respondents to a CBI survey of UK employers reported that staff not performing to their potential capacity causes a loss of productivity at the organisational level (CBI 2011).

Several studies have examined the relationship between office window view content and mental health and wellbeing outcomes specifically. Office workers with views of nature have been found to report less stress (Stigsdotter 2004, Shin 2007, Lottrup et al. 2013), lower levels of tension and anxiety (Leather et al. 1998, Beute et al. 2011) and greater overall subjective wellbeing (Kaplan 1993, Stigsdotter 2004). A study by Leather et al. (1998) focusing on both manual and non-manual workers at an industrial workplace found an interaction effect where those reporting the highest job strain were the most likely to report feeling uptight and harbouring intentions to quit their job, but this effect appeared to be buffered by having a view of natural elements. It seems therefore that window views of nature may play a particularly important role in employees' ability to cope with demanding workloads and/or working conditions. Furthermore, there are indications that views of nature may enhance cognitive functioning at the workplace – in a study of university staff conducted in the Netherlands, objectively measured attentional capacity was found to be positively related to the naturalness of respondents window views (Beute et al. 2011). Such psychological effects may support not only health, wellbeing and productivity but also constructive relationships in the workplace; Kaplan (1993) found that view satisfaction, which related to the amount of nature in window views, was negatively associated with employees' ratings of frustration and positively associated with patience with colleagues. Again there are also economic costs associated with mental ill health. Recent estimates suggest that mental ill health costs Scottish employers over £2 billion

per year through effects on staff absence, presenteeism and increased turnover, equating to £970 per employee (SAMH 2011).

Finally, job satisfaction has been found to be positively associated with views of nature in the workplace (Kaplan 1993, Shin 2007) . This has implications for levels of employee commitment and engagement, as well as staff turnover levels. Attracting and retaining highly skilled employees is extremely important in knowledge-based industries, as this sector of the labour market is particularly mobile, and highly specialised activities such as research and development may require very specific skills for which there is a limited pool of potential candidates.

The geographical spread of the research discussed above is broad. This evidence from employees and organisations in North America, Northern and Southern Europe and East Asia converges in finding positive cumulative benefits of window views to greenspace. This body of international research indicates that window views of nature may have a profound effect on the health, wellbeing and attitudes of employees and therefore the economic performance of organisations. However, there are limitations inherent in many of these studies that should also be recognised. In samples drawn from a number of different workplaces in a range of urban areas (e.g. Stigsdotter 2004, Lottrup et al. 2013) or distributed across the rural-urban gradient (e.g. Shin 2007) there is a possibility that view naturalness will covary with levels of urbanity, and unless this is controlled for in analysis there is potential for a number of factors (e.g. traffic noise, air quality, building density or commuting practices) to confound the measured relationship between green views and wellbeing outcomes.

Other potential confounding factors relate to the other benefits of windows in the workplace, such as providing natural daylight. It could be argued that when comparing views over open space to those facing directly onto other buildings, the benefits of the green view could potentially relate more to the daylight levels offered by an open aspect than the content of the view itself. This is typically a difficult factor to control for in cross-sectional studies as robust measurement of daylight levels requires access to the indoor environments in question and specialised equipment to measure levels of illumination. Some studies have, however, accounted for this potential confounding factor and still found positive effects of natural views. Leather et al. (1998) included objectively measured levels of illumination and extent of sunlight penetration in their analysis, and found that nature in window views did have a distinct influence on wellbeing but that the effect of sunlight exceeded that of view content. Similarly, Beute

et al. (2011) found a positive effect of nature in views when controlling for objectively measured light levels. Both studies indicated that absolute levels of illumination were unconnected to employee wellbeing and functioning, so it seems that although sunlight may be an important benefit of windows, what can be seen in the view is more important for wellbeing than the general light levels provided by windows (Leather et al. 1998, Beute et al. 2011).

In line with these studies, Aries et al. (2010) reported no effect of subjective ratings of light quality on wellbeing; however this study provides some contrasting evidence to the other studies on office window views and wellbeing. In a path analysis, when controlling for light quality as measured through self-reports by employees, they found a *direct negative* association between ratings of comfort (which included dimensions relating to fatigue, concentration levels and headaches etc.) and nature views in offices. Conversely, there was also an *indirect positive* relationship between psychological comfort and nature views – views containing nature were associated with higher ratings of view quality and more positive impressions of the office environment, both of which related to reduced discomfort in the office. The findings of this study highlight the complexity of the relationships between different aspects of the physical work environment, employee perceptions of the environment, and wellbeing. Although indirect relationships were found that were consistent with other research on window view content and wellbeing, this study stands alone in finding evidence of a negative effect of viewing nature in workplace window views. This suggests that there is still a need for further research on the subject, and points to the value of exploring indirect as well as direct relationships between environmental and psychological variables.

Discrete effects of viewing nature through windows in the workplace

A small number of studies have used experimental designs to explore the restorative benefits of relatively short, discrete exposures to green window views in the workplace context. Due to the difficulties associated with manipulating views and controlling potential confounding factors such as sun or daylight, these studies have often used simulations or proxies for window views as these are more easily manipulated.

One study by Hartig et al. (2006) focused on actual window views, using a single room in which the view was manipulated by opening and closing blinds. This study found that cognitive performance varied depending on the view conditions in which subjects undertook periods of work punctuated by short five minute breaks. Cognitive

performance did not differ before and after a break in the no view (blinds down) condition, whereas when a view of trees was available performance increased significantly as a result of the short break. When only a view of a wall was available cognitive performance actually declined over the course of a break. This result speaks to the importance of environment during work breaks, and indicates that even quite short breaks in an indoor environment with a view of greenspace may lead to measurable benefits to cognitive functioning, which itself has profound implications for employee productivity and performance as well as wellbeing.

Other experimental studies have investigated effects on stress rather than cognitive outcomes. Chang and Chen (2005) measured physiological stress (as measured by brainwave activity, muscle tension and pulse) and self-reported anxiety levels in response to viewing images of an office environment where window view conditions were manipulated digitally. Objective stress and subjective anxiety were highest when viewing a windowless office, and when windows were included natural views were associated with lower stress and anxiety levels than city views. Kweon et al. (2008) investigated the impact of different contents of wall art on stress and anger in response to computer tasks designed to frustrate participants. Performing the task in the presence of paintings of nature resulted in lower self-reported levels of anger and stress than in the conditions where either abstract art or no art was presented on the walls. There was, however, a significant gender effect, where this apparent benefit of paintings of natural landscapes was only experienced by men. It was suggested that this interaction effect may be due to differences between men and women in their general levels of anger and willingness to express anger, or that the tasks performed were more effective in provoking anger in men than in women. Although this study suggests a benefit of including wall art in offices, it is not clear from this research whether the advantage of natural landscapes over abstract art is down to the natural subject matter or simply that landscapes of any type are more easily comprehended than abstract images.

Finally, although not an example of a quantitative experimental study, it is worth noting the qualitative field study by Friedman et al. (2008) which involved an intervention introducing plasma screen televisions into windowless offices to simulate views to the outside world. The screens showed a live camera feed directed towards a public plaza containing a large fountain, grass, trees and buildings. Occupants of the rooms reported that the simulated window view made them more creative in their work, helped them to think better and made them feel physically healthier. The results of the study suggested

that the participants did use the display to gain micro-restorative experiences; the authors note that participants 'often took brief mental breaks and stared out the large display window and said that they returned to their work a bit more refreshed and refocused' (Friedman et al. 2008:462).

These experimental studies point to the benefits of having a workplace window view to the outdoors, especially if this view contains nature. They provide some evidence of benefits to stress levels and cognitive performance as a result of fairly short exposures to green views as opposed to grey views (Chang and Chen 2005, Hartig et al. 2006). It also seems that the negative impact of working in a windowless room may be mitigated by including proxies such as landscape art or digital windows (Kweon et al. 2008, Friedman et al. 2008) .

3.2.2 Use of greenspace and employee wellbeing

Hartig (2006) argues for the potential of short 'booster breaks' as a way to counter the negative health effects of work-related stress, emphasising the need for future research to include questions about how the environment in which breaks are taken influences the benefits derived. Research on the benefits of exposure to nature in the workplace context has, however, tended to focus on views and other aspects of the indoor working environment; the potential benefits of outdoor experience in greenspace at the workplace have largely been overlooked.

Analysis of data from a large scale survey in Sweden, reported by Stigsdotter (2004) and Lottrup et al. (2013) included opportunities for physical access to greenspace during work breaks as part on an index of greenspace access at the workplace. Having physical access to greenspace as well as visual access was associated with the lowest levels of self-reported stress in the sample. Those who had neither visual nor physical access displayed the highest stress levels. There was, however, a gender effect detected; for women there was no difference in the stress levels of groups assigned by levels of visual and physical access to greenspace. The authors suggest a number of factors that could explain this lack of an effect of access to greenspace on women, e.g. differences between the sexes in terms of underlying stress levels, responses to different types of stressor, or differences in the actual use of the greenspace resource.

Only two studies have addressed the impact of actual *use* of greenspace during the working day on employee wellbeing. Lottrup et al. (2012) examined employees' use of outdoor areas such as green courtyards and roof terraces, parkland and woodland areas

at a number of knowledge-sector workplaces in Denmark. This study found no association between the frequency of use of such spaces and outcomes such as self-reported health, job satisfaction or employees' evaluations of their work performance. It was suggested that one reason for this could be that even if the greenspace was not used, employees had exposure to it through window views and in passing through on their way to work. In contrast, a study by Largo-Wight et al. (2011) used an index of nature contact at work which included dimensions relating to frequency of outdoor breaks, along with other types of nature contact such as through window views, indoor plants, and photographs of natural landscapes. Employees with high nature contact scores overall, and those with high scores on the outdoor nature contact dimension reported significantly less stress and better general health than the low contact group (Largo-Wight et al. 2011).

Those studies that have considered both the potential for restorative effects of views and outdoor use have tended to combine these into indices of greenspace exposure (Stigsdotter 2004, Largo-Wight et al. 2011, Lottrup et al. 2013). Treating window views and use of greenspace separately could arguably add greater value as this could allow investigation of the differential effects of viewing from indoors versus immersive experiences in green environments at the workplace. Also, as both would be expected to provide opportunities for restoration, examining either without controlling for the other could potentially lead to omitted variable bias, resulting in a masking of the true effect of the single greenspace variable being tested.

The studies discussed in this section provide some early indications that, as would be expected from the wider evidence on the restorative effects of greenspace experience, spending time in greenspace at the workplace may promote employee health and wellbeing. Future research should consider the potential for selection bias, which is much more likely in the case of use of greenspace than views, since employees often have no control over their view whereas taking work breaks outside involves making the decision to do so. It may be that certain underlying personality traits or other factors relating directly to wellbeing could at the same time influence decisions to spend time outdoors and therefore confound observed relationships between wellbeing and use of workplace greenspace. None of the studies discussed above report taking account of leisure time greenspace exposure. It is likely that those who spend more leisure time outdoors in natural environments would be somewhat more inclined to spend time outdoors at the workplace, therefore it is not clear from the existing studies whether

workplace greenspace use is beneficial *per se*, or whether this might simply act as a proxy for overall greenspace exposure across life domains. Activities performed in workplace greenspace also have the potential to confound the relationship between greenspace exposure and wellbeing. Efforts to separate out the effects of physical activity and restoration as a result of the perception of the green environment would therefore be of value.

3.2.3 Indoor plants

Several studies have investigated the effects of introducing indoor plants to workplace environments. Although indoor plants are not within the scope of the empirical investigations undertaken in this project, these studies remain relevant to the evidence base on the role of nature at the workplace for employee wellbeing.

Experimental studies indicate several positive effects of introducing plants to working environments, including improvements in cognitive performance, attentiveness and mood, reductions in physiological stress and symptoms of ill-health and discomfort, and even heightened tolerance to pain (Lohr et al. 1996, Fjeld et al. 1998, Larsen et al. 1998, Chang and Chen 2005, Bringslimark et al. 2009, Raanaas et al. 2011). However, the evidence from experimental studies is somewhat mixed, with several studies finding no effects of plants (Bringslimark et al. 2009, Evensen et al. 2013) and one even finding a negative relationship where more plants was associated with lower productivity (Larsen et al. 1998).

Cross sectional studies investigating the potential cumulative effects of plants in office environments have found the presence of plants to be associated with higher productivity, higher job satisfaction and overall quality of life, and fewer days of sick leave (Bringslimark et al. 2007, Dravigne et al. 2008). Whilst indoor plants may be expected to add to the restorative potential of office environments, they also have a positive effect on air quality in offices by producing oxygen, absorbing carbon dioxide and other gases, and filtering particulate matter from the air (Dravigne et al. 2008). Poor air quality has been linked to Sick Building Syndrome, a term associated with a range of symptoms from irritation of the eyes, nose, throat and/or skin, to headaches, fatigue and difficulty concentrating (Raynor 1997), with indoor plants having been found to reduce the prevalence of such symptoms (Fjeld et al. 1998). It is therefore possible that many of the longer-term benefits of indoor plants in the workplace are due to their effect on air quality rather than their aesthetic qualities. Bringslimark et al.

(2007) have, however, found evidence of residual benefits to productivity and reduced sick leave after accounting for respondents' subjective assessments of the air quality in their office.

Overall, it appears that the evidence on indoor plants and views, along with the emerging research on direct access to and use of greenspace at the workplace, converges in finding positive effects of exposure to green nature at work on employee health and wellbeing. The psychological benefits of nature contact in the workplace contact may also have wide-ranging effects on employee productivity, engagement and interactions, absence rates, and staff turnover; this evidence suggests that there is also considerable scope for businesses to derive economic returns on landscape investments, although the extent of these potential economic benefits is as yet unknown.

3.3 Engagement with greenspace in the context of the workplace

Although several studies have reported on the apparent restorative benefits of greenspace at the workplace, few have addressed the nature of employees' day-to-day engagement and interactions with the outdoor environment of their workplace. The following section provides an overview of existing research on how people relate to greenspace at workplaces; the extent to which they engage with it and the factors influencing these person-environment relationships.

3.3.1 Use of workplace greenspace

Few studies have explored the extent to which people use greenspace resources accessed from their place of work. These greenspaces may form the setting of the workplace, as is the case with science parks and other low density campus-style commercial developments; these developments sit within a designed green landscape, and due to their largely peri-urban location may also offer access to areas of a more typically rural character in the surrounding landscape. Stand-alone developments, both at the urban fringe and elsewhere may benefit from landscaped and garden areas providing direct access to an outdoor green environment from the building. Greenspace opportunities for those in city-centre offices are, on the other hand, more likely to rely on convenient access to public parks and other urban open spaces, although green roofs and internal courtyards may offer small yet potentially rich outdoor environments as part of the architecture of the building itself.

Lottrup et al. (2012) investigated employee use of greenspaces in the immediate vicinity of offices - these included courtyards and roof terraces, on-site gardens and woodlands. The results of this study, conducted in Denmark, suggest that employees' use varied significantly between these different types of space. Overall, 37.8% of the 402 employees surveyed spent time outdoors during their working day on at least a weekly basis, with significant differences in use levels across the six study sites. It is unclear, however, as to how much of this variation stems from the differences in the character of these outdoor environments as opposed to organisational cultures at the different sites studied. Activities commonly performed by workers during breaks in greenspace include having lunch, meeting and talking to colleagues, taking a stroll, passive relaxation, enjoying sunshine and taking in the sights and sounds of nature (Cooper Marcus and Barnes 1995, Lottrup et al. 2012).

Hitchings' (2010, 2013) has investigated use of nearby greenspaces and outdoor breaks by London city-centre legal professionals using a qualitative approach. This study reported minimal engagement with greenspace on the part of these workers, with little time spent outdoors during the working day regardless of environment. Outdoor experience did not feature at all in most of these employees' work days, with participants commonly describing forgetting about the world outside the office entirely, and not even considering opportunities to leave the building. Hitchings' analysis speaks to the pervasiveness of indoor norms, concluding that in light of such norms studies may benefit from approaching the question of outdoor experience in the workplace context from 'the inside out' (Hitchings 2010). From this perspective, understanding how to encourage workers outdoors may be a more pressing research question than that of whether use of open space during the working day benefits health. Workplace norms, values and practices may vary in different organisations, industries and professions, different geographical locations and levels of urbanity. Open space policy development would therefore benefit from further in-depth research on relationships with greenspace in the workplace context.

3.3.2 Drivers of and barriers to use of greenspace during the working day

Recent research conducted in central Scotland sheds some light on what appears to be a key factor influencing decisions to spend time outdoors during the working day. This survey of organisations in the area of the Central Scotland Green Network found evidence of a distance decay in use of greenspaces by employees (Primrose and Mulholland 2010), in line with studies of greenspace use in residential contexts (e.g. Nielsen and Hansen 2007, Scottish Government 2012c). Of the companies reporting having access to greenspace directly outside their building, 44% of companies reported that these spaces were used on a daily basis by employees, whereas only 18% of companies with greenspace less than 5 minutes away, and 10% of those with greenspace at a greater distance reported daily use by employees. Almost half of businesses whose nearest greenspace was more than 5 minutes walk away reported that these spaces were never used by their employees. This is interesting given that the greenspace outside buildings were reported to be primarily grassy areas, with only around half containing seating, paved areas or flower beds that would indicate a more formal garden area. It seems that in most cases even rudimentary greenspaces adjacent to workplaces are used by employees to some degree. These figures do not, however, reveal a great deal about the frequency, duration and nature of individuals' engagement with workplace greenspace.

Demographic factors may also play a part in influencing use of workplace greenspace. Hitchings (2010) reports that in the small sample of legal professionals working in central London younger workers were more inclined to venture outdoors, with the implication that over time workers become somewhat institutionalised into professional norms of eschewing relaxation during the working day. This observation of age differences may also relate to responsibilities, as more junior employees may be less burdened with responsibilities that might discourage others from taking the time away from their desks. In contrast, the quantitative study of use of greenspaces associated with office buildings by Lottrup et al. (2012) found no significant effects of either age or managerial position on workers' frequency of outdoor breaks at any of the businesses studied. This study did, however, highlight a gender difference in use of these outdoor spaces, with men twice as likely to spend time outdoors at least once a week. This gender effect was observed in all but one of the six companies studied. This finding is in line with other studies of greenspace use suggesting that men make more use of

greenspace than women (Ward Thompson et al. 2003, Cohen 2007, Tzoulas and James 2010).

The study by Lottrup et al. (2012) indicates that the root cause of this gender divide in use of workplace greenspace related to differences in the barriers perceived by men and women; more women than men considered themselves too busy to spend time outdoors. This was the most commonly reported barrier to use across the sample. Aspects of this barrier are also described by Hitchings (2010), who explored office workers' tendency to stay indoors in relation to the theme of purposefulness; interview participants felt that having a great deal to do meant that the best use of time was to simply 'get on with it'. There was an overall reluctance to break the momentum of productivity with a period of relaxation which would constitute too much of a change of pace.

Workplace social norms and the perceptions of others as to what constitutes productive use of time may also act as a barrier to use. The idea that managers may perceive taking time to go outdoors as 'having a jolly' has been reported as a constraint to employees' use of hospital grounds (Munoz and Nimegeer 2012). City centre office workers have reported feelings that it is only appropriate to go out if they have an 'outdoor alibi' i.e. a functional reason such as visiting the bank or post office (Hitchings 2010). However, the attitudes of others can also encourage use of workplace greenspace; those who receive encouragement to go outdoors by managers or colleagues are much more likely to take outdoor breaks on a regular basis (Lottrup et al. 2012).

Environmental conditions may also act as both drivers and barriers to use of workplace greenspace. Aspects of outdoor environmental experience considered to be unpleasant (e.g. bad weather, muddy paths, presence of insects) may put workers off going outdoors, whereas sunshine and good weather on the other hand encourage use of the outdoor space (Hitchings 2010, Munoz and Nimegeer 2012, Lottrup et al. 2012). The physical environment may attract or deter employees depending on the individual and the specific context - whereas hospital workers have reported feeling avoiding woodlands because of personal safety concerns (Munoz and Nimegeer 2012), university staff are reported to be drawn to woodlands due to desires for quiet reflection away from the stimulation of busier areas on campus (Abu-Ghazzeh 1999). Specific qualities of workplace open space observed to be positively associated with use by office workers include a serene character, plentiful nature, and the affordance of refuge (Lottrup et al. 2012). Environmental preferences and use of open space in recreational contexts has been conceptualised in terms of orientations towards seeking stimulation

on the one hand, or avoiding it on the other; when looking to avoid stimulation people are drawn to greenspace as opposed to the social stimulation of urban environments (Staats et al. 2003, Frick et al. 2007). Such orientations to relaxation versus stimulation may be dynamic and related to restoration needs, rather than fixed within the individual (Staats et al. 2003). Similar processes may operate in the workplace context e.g. with respect to employee decisions to take a solitary walk in workplace greenspace versus spending the time indoors chatting to colleagues.

3.4 Conclusions

3.4.1 Restorative effects of nature at the workplace

A number of studies have investigated the influence of nature at the workplace (whether in the form of green views, taking breaks in greenspace, or the presence of indoor plants) on outcomes relating to employee wellbeing. Cross-sectional studies have found evidence of beneficial effects of workplace nature contact on a variety of outcomes including physical health, stress and wellbeing, cognitive functioning and productivity, interpersonal relations, and job satisfaction.

Such cross-sectional research benefits from high external validity – these studies provide evidence about effects occurring in real-life contexts. They can, however, suffer limitations in that they may be vulnerable to confounding factors not measured, and even when potential confounding variables are accounted for they cannot prove a directional causal effect. Evidence from experimental studies compensates for these limitations. Although there is a limited experimental evidence base on the effects of workplace greenspace or nature in general, and much of the available research has used samples of students rather than members of the target population of workers, the experimental studies add significant value to the literature. These studies corroborate the findings of the cross-sectional survey research and add further support to the growing body of evidence suggesting that views and outdoor engagement with greenspace at the workplace offer employees important opportunities for restoration during the working day. These restorative effects of nature in the workplace context may lead to cumulative benefits to employee health, wellbeing and performance. Furthermore, the studies reviewed here indicate that not only is workplace greenspace a valuable resource for employees, but the benefits they derive from it could potentially translate into economic benefits for organisations. There is therefore a clear business case to be made for organisations to consider access to greenspace (both physical and

visual) in location decisions and for investments in the landscape of business sites to promote both restoration and use by employees.

Gaps in the research

Given the potential for social and economic gains as a result of visual and physical access to workplace greenspace demonstrated in the research, one element of the future research agenda on this topic could be to quantify the economic value of workplace greenspaces. Approaches such as calculating social return on investment (SROI) in business site landscapes could be of great value in communicating the underlying business case to organisations and developers.

The existing research has found evidence of the restorative value of workplace greenspace in employee populations in Europe, North America and East Asia, however there is a lack of research on the restoration benefits of exposure to workplace greenspace in the UK context. Evidence on these person-environment relationships with respect to the knowledge-sector workforce in the UK would help to build a stronger basis for informing planning policy on a national (UK and Scotland) level as well as regional and local policies and planning guidance.

Also, as highlighted in section 3.2.1, studies have tended to focus on the effects of visual access to greenspace, and more research on the benefits of spending time outdoors in green environments specifically during the work day is warranted. Another feature of the body of research reviewed here is that although it seems clear that window view content does matter, none of the reviewed studies has gone further than distinguishing between natural and built views, or views with more or less natural features. This raises the question of whether the composition of natural features in office window views makes a difference – is viewing lawns as beneficial as viewing trees or water bodies, for example? Going beyond the natural-built dichotomy in studies of the restorative properties of workplace greenspace would help us to begin to understand how we can best plan and design open space at knowledge-sector workplaces.

3.4.2 Outdoor engagement with workplace greenspace

To capitalise on the potential benefits of outdoor experience of green environments at the workplace it is first necessary for employees to take advantage of opportunities to access greenspace resources available to them. Rather few studies to date have explored

employees' use of greenspace during the working day. Those that have suggest that use levels are very variable and depend on a number of factors including:

- Distance to greenspace from the workplace (or more specifically, the time required to reach it on foot);
- Demographic factors, notably gender (with women reporting less frequent use) (Lottrup et al. 2012).
- Considerations of time pressure, workloads and both personal and social norms regarding productivity during working hours;
- Environmental factors including weather, objective characteristics and subjective qualities of the environment; and
- Individuals' orientations towards restoration versus stimulation at a given point in time.

In building an understanding of how best to plan and design workplace open space to support employee wellbeing there is still much to learn about how people use workplace greenspaces and the factors influencing decisions to spend time outside and outdoor practices. As highlighted in section 3.3.1 of this chapter, there is as yet little research on people's relationships with open space in the context of knowledge-sector workplaces.

In contrast to the literature on the restorative effects of workplace greenspaces - which has mainly taken a quantitative approach - qualitative research (such as the work of Hitchings) has made a substantial contribution to understanding of open space use by employees. Further in-depth studies focusing on different types of greenspace in different forms of development and organisational contexts could shed light on the commonalities and differences in employee engagement with workplace greenspace in different situations. Qualitative approaches exploring the interactions between practices and experiences in greenspace could make a similarly valuable addition to the literature on restorative environments in the work domain. Qualitative approaches have seldom been applied to the study of the wellbeing benefits of greenspace in general (Dinnie et al. 2013) but have the potential to both broaden and deepen understanding on the meanings of greenspace as experienced in different life domains and social contexts.

Chapter 4: Case studies

4.1 Introduction

This chapter introduces the case study methodology adopted in the study. The detailed methods of data collection are presented later in chapter 5, however it is first necessary to first set out the rationale behind the decision to focus on science parks to study person-environment relationships with workplace greenspace. The choice to base the research on this particular development form preceded decisions regarding particular data collection methods; the design of the data collection strategy and materials was therefore heavily informed by the particular opportunities and constraints of science parks as a research setting. It is for this reason that the discussion of the methodology will begin by situating the research within the open space of the science park study sites. To this end, the present chapter opens by defining science parks and their objectives (section 4.2.1), and gives a brief overview of the evolution of this development form in response to the growth of the knowledge economy (4.2.2). Section 4.2.3 highlights critiques surrounding the spatial form and environmental quality of campus-style business sites in general and science parks in particular. These together form the background to the rationale for focusing the study on science park open space, as set out in section 4.2.4. The planning context for the development of science parks in Scotland is then outlined in section 4.3. The largest part of the chapter is dedicated to presenting the case study research design (section 4.4) and describing the study sites (section 4.5).

4.2 The science park development form

4.2.1 Defining Science Parks

Science parks are differentiated from other forms of campus-style business development such as business parks, not so much by their form but by their aims and institutional structures. Massey et al. (1992) note in their book *High Tech Fantasies: Science Parks in Society, Science and Space* that 'there has been explicit consideration of what does and does not qualify for membership of this quite carefully defined group' (p.13). In the UK the accepted definition of a science park was established in 1985 by the newly formed UK Science Park Association (UKSPA).

The current definition used by UKSPA states that:

'A science park is a business support and technology transfer initiative that:

- *Encourages and supports the start-up and incubation of innovation-led, high-growth, knowledge-based businesses.*
- *Provides an environment where larger and international businesses can develop specific and close interactions with a particular centre of knowledge creation for their mutual benefit.*
- *Has formal and operational links with centres of knowledge creation such as universities, high education institutes and research organisations.'* (Parry 2006, UKSPA undated-d)

The general term 'science park' encompasses all property-based initiatives which fulfil these three criteria outlined above, though they often go by different names – 'research parks', 'innovation parks/centres', 'technopoles', 'technology parks' and 'high-tech parks' to name a few. 'Research park' is the most common term used in the USA, and was adopted for the first generation of property-based initiatives linking higher education institutions (HEIs) and business established by Heriot-Watt and Cambridge Universities. In subsequent decades the term 'science park' has become the most common term used in the UK and the rest of Europe (though 'technopole' is particularly common in France), and in Asia such developments are more often known as 'high-tech parks' (Massey et al. 1992, Link 2009).

4.2.2 The evolution of the Science Park development model

The proliferation of science parks and other campus-style business sites on the periphery of British cities can be seen to stem from a development model originating in the United States in the middle of the 20th century, the spread of which has accompanied the rise of knowledge-based industries worldwide (Aslin 1991, Moore 1991, Westhead and Batstone 1998). The early model established in the US evolved from industrial parks, where similar industrial uses are concentrated in one location. The growth of the high-tech research and development economy, dominated by electronics and IT-based businesses spawned a shift in priorities for location, resources and environment. The hub which has come to be known as Silicon Valley began as a collaborative property-based initiative between Stanford University and private-sector businesses in 1946, and later in the 50s the Stanford Industrial Park (now Silicon Valley) was established and set the trend for regional development through hi-tech industries for the rest of the US (Rosenblum 2004). In the 1960s and 70s the development of the field of biotechnology

added to the growing range of high-tech industries, and alongside the decline of traditional manufacturing industries and shifts in employment towards the knowledge-based and service sectors, demand for commercial development continued to move towards locations outwith traditional city centre business locations and industrial parks. The new 'sunrise' industries demanded locations offering space for low density development, car-parking, good transport links and high quality and flexible accommodation in an attractive setting capable of attracting and retaining high-skilled staff (Moore 1991, Aslin 1991).

The earliest examples of this trend in the UK aimed to draw from the successful models of university-based developments for high-tech industries in the US established at Stanford, Duke and other American universities. Wilson and Bardell (2006:169) state that 'Scotland has been identified as leading the way in delivering the science park model in the UK'. Cambridge University and Heriot-Watt University were first to establish associated research parks in the early 1970s, but it took another decade before other universities and research institutions followed suit (Holden 1992, Henneberry 1992, Westhead and Batstone 1998). High-tech industries led the way in the early to mid 1980s, where developments commonly incorporated industrial use on the ground floor with office use above. In the latter part of the 1980s other knowledge-based businesses that had previously favoured city-centre office locations began to be drawn to the advantages of campus-style developments like science parks, and this in turn led to the creation of the office-based model of the business park (Bragg 1991, Henneberry 1992).

4.2.3 Science Park landscape

The science park setting is seen by some as a valuable asset for companies in attracting and retaining high quality staff, and also in serving as a symbol of status. Massey and colleagues' analysis of the spatial form and physical environment of the science park development model emphasises the idea that these aspects set the sites (and by extension the firms located on them) apart from the norm – 'the defining characteristic of the physical design of the parks and the way in which they were promoted, was that of high status, a prestige environment' (Massey et al. 1992:161). Other authors have described the science park environment as being symbolic of something new and better than what had come before. Gallent et al. (2006) for instance, discuss Castells and Hall's description of the science park setting resulting from the technological revolution

and the ‘new economy of the fringe’ as the antithesis to the places shaped by the industrial revolution:

> *If ‘the coal mine and its neighbouring iron foundry, belching forth black smoke into the sky’ was the image of the nineteenth-century industrial economy, the corresponding image for our contemporary economy ‘consists of a series of low, discreet buildings, usually displaying a certain air of quiet good taste, and set amidst impeccable landscaping in that standard real-estate cliché, a campus-like atmosphere’* (Castells and Hall 1994, in Gallent et al. 2006:43).

The original vision had been for 'new highly serviced, well-managed business environments in twentieth century equivalents of the English landscape garden or (equally relevant) the masterplanned campuses of the early twentieth century American universities' (Holden 1992:10). There has however, been some criticism of the manner in which the campus-style business site model has been delivered in the UK. The context for planning such developments in the UK is very different to that of US cities (development land is a scarcer commodity and planning control has been tighter) and this, it has been argued, influenced the British versions of the American model (Holden 1985, Bragg 1991). As early as the mid 1980s concerns were being voiced about the quality of the landscape, with the planning constraints at the urban-fringe and the risk associated with investment seen as contributing factors resulting in missed opportunities where 'too often landscape is defined as just green ink on a plan and words in a section 52 agreement, rather than a basis for design' (Holden 1985:530). Holden asserts that both business and science parks as they have been delivered in the UK have 'too much of the car park and too little of the country park' - that overdevelopment of sites and high parking provisions has meant that 'the usual ‘low density’ approach to business development results in the office users having a view over a sea of cars' (Holden 1992:12). Others have criticised science parks for lacking distinctiveness; Gallent et al. (2006) comment that like business parks, science parks 'have a similar reputation for architectural blandness and uniformity' and argues that science parks look the same wherever you go in the world, and thus cannot escape a sense of anonymity that lends them to be classified as ‘non-places’. In contrast, other researchers have highlighted examples of innovative placemaking approaches to the design of science park landscapes e.g. in applying ecological design in conjunction with traditional feng-shui principles in the design of a site in Shenzhen, China (Fang and Xie 2008).

Much of the recent literature on science parks relates particularly to their institutional structure and knowledge-transfer functions as being the key to their success, with

discussions of issues relating to the physical environment seemingly less prominent in the discourse (e.g. Rosenblum 2004, Fukugawa 2006, Link 2009, Carvalho 2009). This is despite the fact that locational factors and factors relating to the physical environment and the prestige of the development as a whole have been valued more highly by employers in their decisions to locate there (Westhead and Batstone 1998, Investment Now 2004). Others have emphasised the strategic role of science parks and clusters in regional development and creating employment growth in areas which have suffered the most from declines in traditional industries (Westhead and Batstone 1998, Batham 2006). At times this economic discourse surrounding science parks appears to take the environmental quality of science park locations as a given e.g. Zhang's (2004) paper on critical factors for science park management mentions landscape only briefly, arguing that 'a beautiful landscape' is not enough on its own to attract tenants and does not determine a park's ultimate success. Overall it seems the limited discourse on the science park environment highlights contrasts both in perceptions of the quality of the environment that is typically delivered and also of the importance that the landscape plays in the viability of science parks as property-based initiatives.

4.2.4 An ideal setting for restoration?

The characteristic spatial form of campus-style developments like science parks - low density development with high proportions of open space and a parkland setting - and the fact that they are in most cases located at the urban fringe, means that they potentially offer workers substantial opportunities for interaction with greenspace during the working day. These opportunities for visual and physical access to nature could mean significant potential for wellbeing benefits.

Science parks cater exclusively to knowledge-sector businesses, to which it could be argued that employee wellbeing is of particular relevance as human capital lies at the heart the productivity of these organisations (de la Fuente and Ciccone 2003). Attracting and retaining highly skilled employees is therefore of critical importance, and for workers to apply their skills to their maximum potential optimal psychological functioning is desirable. There is, in fact, evidence to suggest that the relationship between employee wellbeing and performance is stronger in more complex jobs (Judge et al. 2001). Therefore, we might expect that the population of workers in science parks - given the cognitive demands of their work - would demonstrate great potential to derive restorative benefits from greenspace at work. Furthermore, promoting employee

wellbeing and opportunities for restorative experiences may be of particular value to the knowledge-sector businesses that science parks accommodate.

These aspects of spatial form and setting, coupled with the nature of the activities of the businesses located on them mean that in theory these should be ideal places to observe restorative effects of greenspace at the workplace. However, given the criticisms that have been levelled against the landscape of science parks in the UK, the extent to which these environments serve as a restorative and useable greenspace resource remains in question.

4.3 The planning context for Scottish Science Parks

4.3.1 Development process overview

A range of commercial interests may be involved in developing Science Park sites. Whereas some science parks are owned and managed solely by an HEI, regional development agency, or private developer, often these developments occur as a collaboration between multiple private and/or public-sector stakeholders (Parry 2006, Carver et al. 2006). It is not unusual for the development of individual parks to be a process spanning decades rather than years, as development tends to be phased and often guided by a masterplan (Massey et al. 1992, Carver et al. 2006, Parry 2006).

The development process in Scotland is subject to a hierarchy of development policy under the Town and Country Planning (Scotland) Act 1997, as amended by the Planning etc. (Scotland) Act 2006. This incorporates the statutory development plan hierarchy (outlined below), along with the consolidated *Scottish Planning Policy* (SPP). Science park land uses fall under class 4 of the Town and Country Planning (Use Classes) (Scotland) Order 1997; this relates to office uses other than those falling within class 2 (the latter relating to financial, professional or other services provided to the public in shopping areas), research and development of products or processes, or industrial processes not causing detriment to the amenity of a residential area.

Single-user or multiple-occupancy buildings may be developed by the science park owners/partnership and then leased to tenants, or alternatively plots may be sold or leased long-term for development by companies to their own specification; often science parks employ both of these strategies (Carver et al. 2006). There are often planning obligations imposed under section 75 of the Town and Country Planning

(Scotland) Act 1997 (as amended) to restrict occupancy e.g. to research, development and associated activities only.

4.3.2 National policy

At a national level, the vision for future infrastructural development is set out in the second National Planning Framework (NPF2), with more detailed policy set out in the consolidated Scottish Planning Policy (SPP), replacing the former suite of individual SPP documents. Best practice guidance is set out in the suite of Planning Advice Notes (PANs). National-level policy may also be produced for development areas of strategic national importance (e.g. the West Edinburgh Planning Framework).

A key element of the vision presented in the NPF2 is the promotion of sustainable economic growth by developing knowledge-based industries and knowledge transfer. The NPF2 paragraph 60 identifies the priority sectors for economic development in Scotland (life sciences, energy, financial services, tourism, creative industries, food and drink and electronic markets) and sets out a requirement for the planning system to 'promote opportunities to foster the development of synergistic business clusters, and facilitate the provision of supporting infrastructure'.

The NPF2 also introduced the Central Scotland Green Network as a national development to support coordinated woodland expansion, creation and safeguarding of high quality landscapes, routes for active travel and recreational use, and strategic habitat networks. This intends to build on existing assets such as the Glasgow and Clyde Valley Green Network, the Central Scotland Forest, and the Edinburgh and Lothians Forest Habitat Network. The rationale stated for prioritising this national development is to support the economic competitiveness of Central Scotland and make it a 'more attractive place to live in, do business and visit' (NPF Annex 12).

The consolidated SPP (Scottish Government 2010) supersedes the former subject-based suite of SPPs and the remaining National Planning Policy Guidance (NPPGs) preceding them. The most relevant policy provisions for the purposes of this project include:

- Paragraph 47, which states that 'some specialist activities such as research and development and knowledge-driven industries require locations where there is high environmental quality and connections to relevant academic and research institutions and similar businesses'.

- Paragraph 49, setting out the requirement for SDPs and LDPs outwith city regions to 'identify an appropriate range of strategic business locations such as mixed developments, business parks, science parks, medium and large industrial sites and high amenity business locations'.

- Paragraph 154, which requires LDPs or supplementary guidance to set out requirements for the provision, quality and accessibility of open space as part of new developments. Paragraph 155 promotes the provision of 'accessible, safe, welcoming, appealing, distinctive and well connected' open spaces.

- Paragraph 162 relating to green belts lists types of existing developments that should be excluded from green belt designations, including 'existing major educational and research uses, major business and industrial operations'.

- Paragraph 168 states that 'significant travel-generating uses should be in locations which are well served by public transport and the amount of associated car parking permitted should be controlled to encourage more sustainable travel choices'. Paragraph 172 sets out national standards for parking provision. For use class 4 (business) developments of 2500 m^2 and above the maximum standard is 1 space per 30 m^2.

4.3.3 Regional and local policy

At the regional and local level the development plan is the policy framework on which decision-making is based. In the modernised Scottish planning system the development plan hierarchy consists of the National Planning Framework, cascading into Strategic Development Plans (SDPs) which replace the existing Structure Plans and are being produced or the four main city regions (Edinburgh, Glasgow, Aberdeen and Dundee) and finally Local Development Plans (LDPs), replacing Local Plans and produced by each planning authority. Decisions should fall in line with the statutory development plan unless there are material considerations indicating otherwise. In addition to the development plan, planning authorities produce various supplementary planning documents and guidance such as development briefs, design standards, open space strategies etc. Provisions made in such supplementary planning guidance may be a material consideration in development management decisions.

4.4 Case study design

4.4.1 Rationale for research design

To understand not just *whether* greenspace impacts on the wellbeing of the population of science park workers, but *how*, *why*, and *under what conditions* restoration benefits might occur, a case study research design was employed. Yin (2009:18) defines the

case study approach in terms of its scope – 'an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the *boundaries between phenomenon and context are not clearly evident*' (emphasis added). Since case study research investigates phenomena in their natural contexts, findings are high in ecological validity; case study designs are therefore well suited to exploring effects of place and commenting on impacts of planning and design decisions.

Yin (2009:4) states that 'the case study method allows investigators to retain the holistic and meaningful characteristics of real-life events'. In the context of this study, doing so presents an opportunity to explore not just statistical associations between greenspace and wellbeing variables (through a deductive approach), but also the impact of specific contextual factors and symbolic meanings on restoration (using inductive logic). Little is known about the social and environmental factors which influence engagement with and experience of greenspace in the workplace context. Relationships with workplace greenspace may differ significantly from those related to neighbourhood greenspaces and other greenspace used during leisure time. This is not just because of differences in the character of open space on and around business sites compared to those encountered in residential environments, but also because the workplace context implies different motivations and barriers to engagement, and different priorities and expectancies of users about what open space should offer. The case study approach offers a route to understanding such complex and pluralistic person-environment relationships through an holistic, context-sensitive approach.

This project examined five science park sites distributed across central Scotland. This multiple-case study design was employed to allow analysis of patterns both within and across sites varying in size, spatial layout, open space characteristics and neighbouring land uses.

4.4.2 Site selection

Box 4.1 below summarises the criteria used to select case study sites. The first criterion was geographical. During the early stages of the research design the intention was to focus on science parks within the Edinburgh city region, specifically sites within the Edinburgh Science Triangle. The rationale for this was that the city and its region are renowned for science and technology innovation and is home to a number of science park sites. Overall the Edinburgh city region accounts for 47% of research and development employment in Scotland (SESplan 2011a). The Edinburgh Science

Triangle (EST) initiative promotes the region as a key location for science and innovation, working in partnership with individual science parks, HEIs and key public sector stakeholders. These intentions to focus on EST sites had to be reviewed as several of the parks that make up the EST are still at an early stage and proved to be unsuited to the purposes of this study: either lacking a critical mass of employees on the site, or still undergoing phase 1 construction, landscaping and infrastructural work. Another site was rejected as it did not fit into the campus-style development form of interest in this study, being a single building 'incubator' centre located on a pre-existing industrial park. It was therefore necessary to extend the geographic area of interest to encompass the whole of Scotland's central belt. Although there are also science parks in the Aberdeen and Dundee city regions, the majority of Scottish science park developments lie within the central belt. This area also coincides with that outlined for action in the development of the Central Scotland Green Network (CGSN). For these reasons, and taking into consideration the travel and cost implications, case study sites were confined to the Central Belt.

The second major criterion for case study site selection was that they should be members of the UK Science Parks Association (UKSPA), and therefore meeting the criteria UKSPA set out in their definition of what constitutes a 'true' science park (see section 4.2.1). Of the 10 Scottish parks listed as members of UKSPA at commencement of the study, eight fell within the Central Belt, six of which were well established. Three of these were in the Edinburgh region and had already been identified as suitable study sites. In addition two other suitable sites at Stirling and Glasgow were also identified, giving a total of five study sites. Due to concerns about the potential difficulty of obtaining access to a large sample of employees it was considered necessary to include five sites although original plans had been to study fewer sites in a narrower geographic area. Together these sites represent a range of different spatial forms and open space opportunities for employees. Key features differentiating the character of the sites are their location in relation to a university campus, the model of development (balance between single-user buildings with defined lots vs. multiple-occupancy buildings with shared open space), and access to greenspace elements such as woodlands, watercourses and lochs.

Box 4.1: Key selection criteria for study sites:

- Must be located within the Central Belt
- Must be UKSPA member
- Must a campus-style development (multiple buildings within a wider open space setting managed centrally)
- Must be well-established – with a significant population of employees and established landscaping
- Together, should represent a range of different open space characteristics and green/blue elements

4.5 Study site overviews

This section provides a short overview of each of the science park sites selected as case studies for this research project. The geographic distribution of the study sites is shown in figure 4.1:

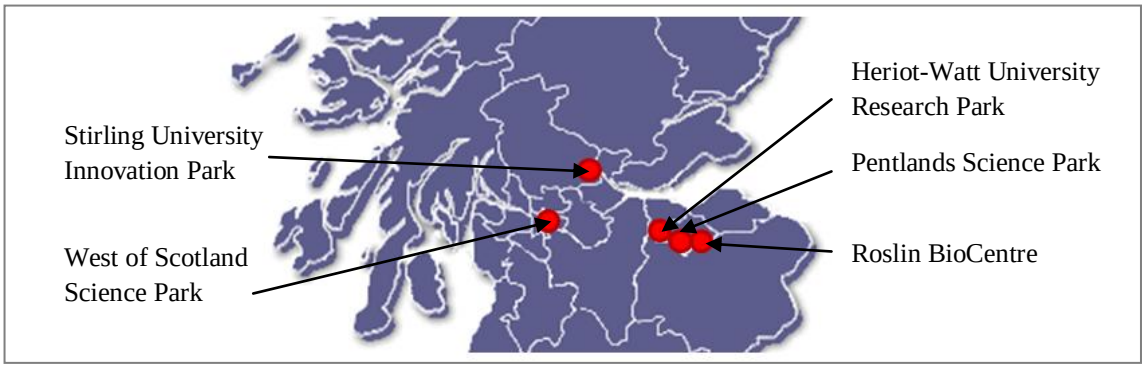


Figure 4.1: Study site location map - Central Scotland

4.5.1 Heriot-Watt University Research Park

Location

Heriot-Watt University Research Park (HWURP) is located at the Western edge of the City of Edinburgh, adjacent to Heriot-Watt University. The research park is to the north of the University's Riccarton Campus, and is adjacent to the city's Hermiston Park and Ride site at the eastern edge of HWURP. HWURP lies around 750 m to the west of the City of Edinburgh Bypass (A720). The northern boundary of the site is marked by the A71, and M8 motorway connecting Edinburgh and Glasgow runs some 250 m to the north of this. A location plan and aerial view of the site are shown in figures 4.2 and 4.3 respectively.

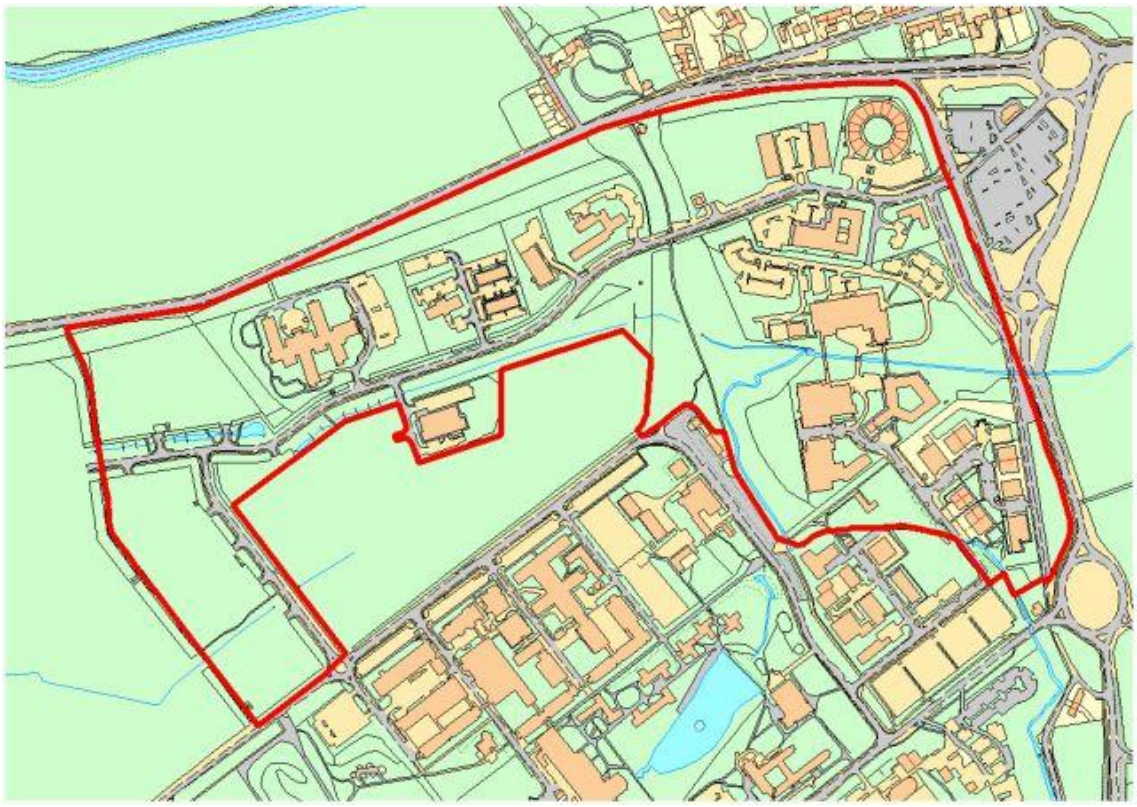


Figure 4.2: Heriot-Watt University Research Park site plan © Ordnance Survey.

Figure 4.3: Heriot-Watt University Research Park aerial view © Bing maps.

Background

The research park is owned and managed by Heriot-Watt University. Established in 1971, it is the first science park to have been developed in Scotland and one of the earliest examples of the application of the science park model in the UK (Henneberry 1992, Westhead and Batstone 1998). The total area of the park is 166 acres (approx. 67

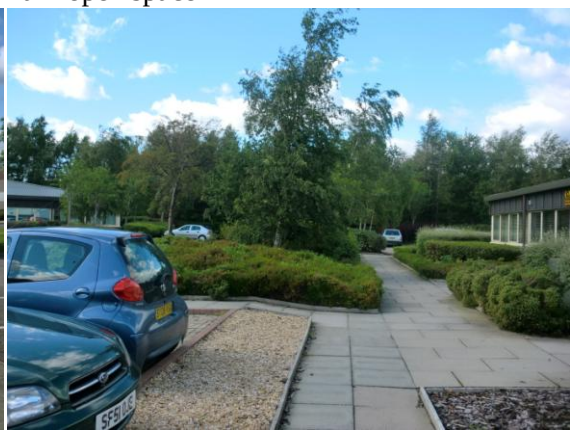
hectares). Of this, 110 acres have been developed, with a further 45 acres available for future development (UKSPA undated-a). In 2011 there were 32 organisations on the site, employing around 1300 staff (based on information provided by site management and organisational contacts). The site contains a mix of primarily one and two storey buildings, incorporating a mixture of office and laboratory accommodation. Some buildings are owner-occupied and custom designed, whereas other are leased with a variety of unit sizes available to accommodate small start-up businesses and university spin-off companies as well as established businesses. The research park focuses on activities such as 'research, development, design, engineering, training, and prototyping activities leading to manufacture' (Heriot-Watt University 2009). Prospective tenants should meet certain criteria in that their activities on the site should include a significant proportion of relating to research and development and should relate to the focus of at least one department of the University, and tenants should also be open in principle to collaboration with the University (UKSPA undated-a).

Site open space characteristics

Given the phased development of the research park, areas within it vary in character. The older area of development (to the east of the site) consists of higher density development characterised by low-rise buildings, access roads and parking punctuated by landscaping features, along with small pockets of amenity grassland in the vicinity of some buildings and communal open space including a seating area overlooking a minor watercourse and a lawn between the research park and the University's Institute of Petroleum Engineering (see figure 4.4a-d). There is a large area of open space in the vicinity of the large single-user facility at the central-east of the site, however access to this area was restricted for the purposes of the study. A security controlled gate to the north and signage discourages public access to this area. The north-western side of the site (fig 4.4e,f) contains the more recent developments, several of which are owner-occupied and designed to owner specifications, resulting in greater architectural variety. This area of the site is characterised by lower density development and larger scale buildings, with larger areas of open space on individual lots as well as communal open space areas and undeveloped land. A multi-use path set within mature woodland (Hermiston Walk) provides a link between the north and south areas of the research park for pedestrian and cyclists (fig 4.4g). An unpaved track through woodland adjacent to the A71 runs along the northern site boundary (fig 4.4h).

Figure 4.4a-h: Heriot-Watt University Research Park open space

a



b

c

d

e

f

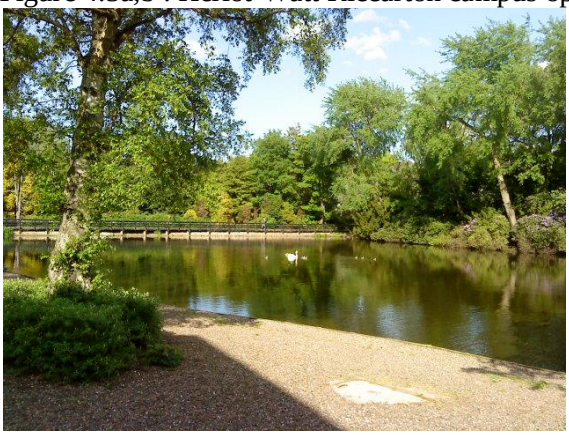
g

h

Setting and neighbouring land use

Neighbouring land uses are primarily educational and agricultural. The adjacent University campus occupies the site of the former Riccarton Estate, offering access to established formal landscaped gardens, a central loch, and mixed policy woodlands (fig 4.5a,b). In 2012 the University was awarded a Green Flag Award for its open space. Other facilities within the main University campus are available to staff at the research park, including food outlets, shopping, banking and sports/gym facilities. Companies on the research park are also able to make use of facilities such as the University library and conference centre. The landscape surrounding the university campus and research park is characterised by agricultural use and transport infrastructure, with views into and out of the site screened by mature tree belts. The closest residential area is Currie, which lies around 1 km to the south of the University.

Figure 4.5a,b : Heriot-Watt Riccarton campus open space features



a

b

Planning context

HWURP lies within the Edinburgh Green Belt. Policy ECON4 of the Edinburgh and Lothians Structure Plan 2015 (approved in 2004) identified the Heriot-Watt University Campus and Research Park as a major established use within the Green Belt. Development within such established green belt uses is accepted in principle due to their strategic importance, and must be in accordance with an approved masterplan (para 4.13). The current Rural West Edinburgh Local Plan (RWELP), adopted in 2006, carries forward these structure plan provisions and retained Heriot-Watt Campus within the green belt designation to ensure that development respects the green belt setting. Policy ED7 relates specifically to the campus, and sets out the purposes for which development will be supported which includes 'research and development of products and processes' along with development relating to teaching, research, accommodation

and recreation at the University itself. In line with the approved 2001 masterplan for the site Policy ED7 states the acceptability of prototyping but not commercial production or manufacturing activities at the site, and a requirement for occupiers' demonstrate links between their activities and the University's academic activities. It also sets out requirements for developments to be acceptable on a number of issues including scale, accessibility, landscape quality and habitat protection, and impact on green belt objectives.

The Edinburgh and Lothian Structure Plan 2015 will soon be succeeded by the new SDP for South East Scotland *SESplan*; the proposed SESplan is, at the time of writing, under examination by the Scottish Government Directorate for Planning and Environmental Appeals (DPEA). The proposed SESplan (paragraph 130) states that existing major educational and research uses should be excluded from green belt designation (in line with NPF2). Policy 11 of the proposed SESplan will require LDPs to identify opportunities to contribute to a strategic Green Network (to include the Central Scotland Green Network), aiming to deliver benefits which include 'supporting sustainable economic development and creating more health promoting environments' (paragraph 126). The Economy Technical Note accompanying the proposed plan notes that meeting land requirements for the Life Sciences key sector 'will require the protection of existing facilities and the provision of sufficient high quality land to be set aside for the future expansion of science parks and campuses' (SESplan 2011a:12).

4.5.2 Pentlands Science Park

Location

Pentlands Science Park (PSP) is located to the south of Edinburgh in Midlothian. The site forms part of a cluster of science and technology sites at the Bush Estate, around 4 km north-east of Penicuik. The site is accessed from the B7006, which lies at its northern boundary. Figure 4.6 shows the boundaries of the site, with an aerial view is shown in figure 4.7.

Background

PSP is owned and managed by the Moredun Group, a limited company and registered charity specialising in animal health research. The park opened in 1995, with development taking place between 1994 and 1999 (Moredun Group undated). PSP is home to the Moredun Research Institute and 21 tenant companies (as at February 2011).

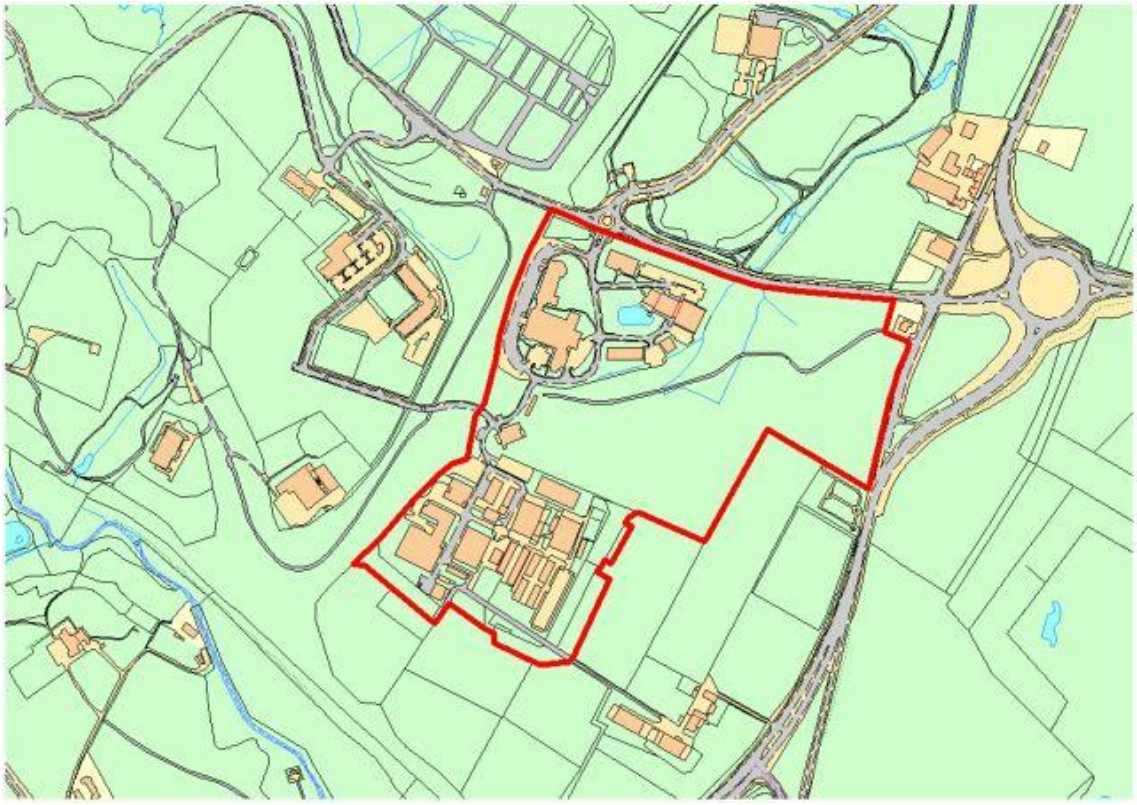


Figure 4.6: Pentlands Science Park site plan © Ordnance Survey.

Figure 4.7: Pentlands Science Park aerial view © Bing maps.

Currently PSP has a total of around 160,000 square feet of office and laboratory space, with around 55,000 sq ft of this occupied by tenants (Moredun Group undated). Farm animal facilities are also included in a separate area to the south-west site. In total around 450 people are based at Pentlands Science Park (Moredun Group undated). Although life sciences makes up the bulk of the activity of organisations at the site, other industries such as optoelectronics, software development and environmental services are also represented amongst the tenant companies.

Open space characteristics

The main area of office and laboratory accommodation at PSP consists of five 1-3 storey buildings situated within landscaped parkland on the north side of the site. Prominent open space features within this area include a central landscaped area incorporating a pond with fountain, flower beds, lawn, structural planting and seating (see fig 4.8a). Car parking provision is largely situated at the outer edge of the development. The design of two of the buildings accommodating tenants incorporate deck/balcony features, allowing direct access to views onto the pond area (fig 4.8a,b). At the south of the site lie the farm facilities and further laboratory and office accommodation. The development lies within a mature woodland setting, limiting views into and out of the site. Mature woodland (fig 4.8g) dominates the east of the site and can be accessed directly from the developed area. A small number of allotment plots (fig 5.8h) are situated at the edge of agricultural land to the south-east of the site, and are accessed through the eastern woodland area.

Figure 4.8a-h: Pentlands Science park open space

a

b

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d

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Setting and neighbouring land uses

PSP is one of several research and development business sites on the Bush Estate at the foot of the Pentland Hills. A security-controlled access road to the west links PSP directly to the adjacent Edinburgh Technopole. Directly opposite PSP lies Scottish Enterprise's Biocampus, the intended development site for a dedicated biomanufacturing campus, as yet unoccupied and largely undeveloped and recently designated as part of the Scottish Government's Life Sciences Enterprise Area under the Government Economic Strategy (Scottish Government 2012a). The nearby University of Edinburgh Easter Bush Campus is home to the Royal (Dick) School of Veterinary Studies and, since 2011, the Roslin Institute. The developments at the Bush Estate are framed by extensive mixed policy woodlands containing a path network linking to neighbouring areas and the Pentland Hills. Other neighbouring land use is predominantly agricultural.

Planning context

The Edinburgh and Lothians Structure Plan 2015 identifies the A701 Corridor as an Economic Cluster of National Importance, setting requirements in policy ECON3 for local plans to support the further development of knowledge-based industries within this

Core Development Area by providing development sites for further expansion of this cluster. The Bush Estate and nearby (former site of the) Roslin Institute are also identified as established green belt uses within the plan (paragraph 4.13). The Midlothian Local Plan (adopted 2008) forms the local tier of the development plan applying to PSP. The plan makes provision for further planned development at the Bush Estate and Roslin Institute as major non-conforming land uses in the green belt (policy RP3) and includes land allocations for biotechnology development (under proposal ECON2) at land currently in agricultural use at the south of the existing PSP site (7.5 Ha) and a further 2.5 Ha allocation to the north on the opposite side of the B7006 (east of the Gowkley Moss Biocampus site). Outline planning permission for a phase 2 expansion of PSP onto the 7.5 Ha site to the south was granted in 2009 (since elapsed). The proposed development site covers not only the area allocated in the local plan but also extends through the woodland to the south of the main area of office and laboratory accommodation at PSP. It was proposed that the development within the woodland would consist of an access road and two buildings (up to 3 storeys in height) (Midlothian Council 2009).

4.5.3 Roslin BioCentre

Location

Roslin BioCentre (RBC) lies around 2 km to the east of PSP in Midlothian, also close to the A701 corridor. The BioCentre is located north of the village of Roslin. Figure 4.9 shows the boundaries of the site occupied by RBC and formerly the Roslin Institute. RBC comprises the two buildings at the north of the site. Figure 4.10 shows the aerial view of the site.

Background

RBC forms part of a larger site for life sciences research formerly shared with the Roslin Institute, which moved to new accommodation at the Easter Bush Campus in 2011 after becoming part of the University of Edinburgh in 2008. Research activities have taken place on the 14 hectare site since 1973, later evolving into the Roslin Institute which was established in 1993 (Roslin BioCentre undated). RBC was established by the Roslin Institute in 1997 as a centre for spin-off commercial activities and incubator facility for new start bioscience research companies. The BioCentre opened in 1999 on completion of the single-storey purpose built Logan Building at the north-east of the site. Expansion took place in 2004 when RBC took over the lease of

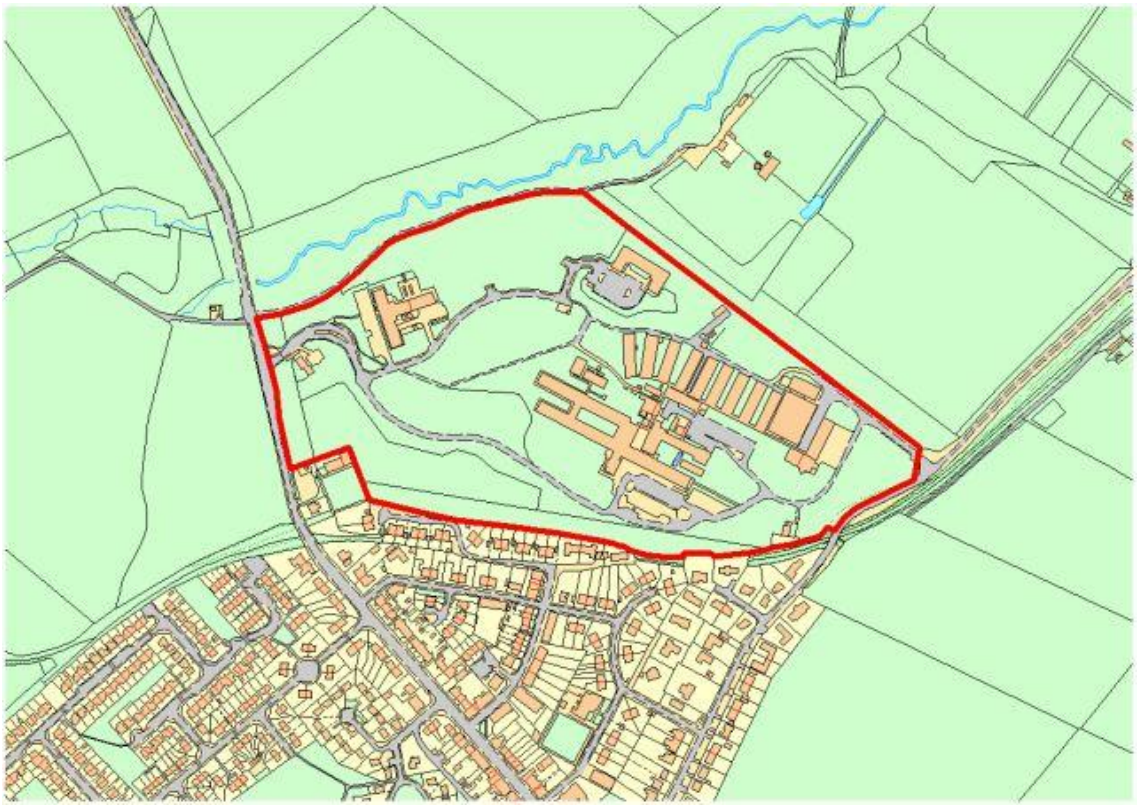

Figure 4.9: Roslin BioCentre site plan © Ordnance Survey.

Figure 4.10: Roslin BioCentre aerial view © Bing maps.

the pre-existing Wallace Building and converted it for multiple occupancy (Roslin BioCentre undated). RBC currently occupies a total of around 6.5 hectares of the wider site (D. Reid, personal communication, 15 Feb. 2011) on a long term lease from the Biotechnology and Biological Sciences Research Council (BBSRC). Serviced units are leased to RBC's tenant companies. In addition to the Wallace and Logan Buildings, a small amount of accommodation is provided in portacabins adjacent to the Wallace

Building. As at 2011 around 120-130 staff were employed at the site, across 22 companies (D. Reid, personal communication, 15 Feb. 2011).

Open space characteristics

The site consists of the two RBC buildings and larger Roslin Institute building (along with its related facilities such as poultry houses), set within parkland consisting of areas of amenity grassland and mature broadleaved trees, with a fenced-off pasture area (used for sheep grazing) lying between the Wallace and Logan Buildings at the north of the site. At the entrance to the site there are also childcare facilities occupying two small low-rise pitched-roof buildings and a portacabin. Car parking for the Wallace and Logan Buildings is located directly in front of the buildings, and the other car parks serving the Roslin Institute are largely not visible from the RBC buildings, the exception being the small parking area serving the on-site nursery. The car parks serving RBC and the nearby nursery are fronted by areas of structural landscaping consisting of shrubs and tree-planting (fig 4.11a,d,e). Seating areas are provided at both the RBC buildings, at the front (south side) of the Logan Building overlooking the car park (fig 4.11e), and at the north side of the Wallace Building (fig 4.11f) overlooking pasture and nearby woodland to the north as well as the RBC facility to the south. The main access road to the former Roslin Institute facilities (located to the south of the site) is lined with mature tree planting and therefore has limited visual impact from the RBC site. Overall the site area occupied by RBC has an open and rural character due to the mix of parkland and agricultural fields, however as with other sites, woodland and tree planting provides screening and limits views to the surrounding landscape from most areas within the site.

Setting and neighbouring land uses

The setting of RBC is predominantly rural, with agricultural land use dominating the wider area and views to the Pentland Hills. A bowling club and residential development at Roslin lie to the south of the site. Views into and out of the development in this direction are restricted by woodland, however there is pedestrian access from the south side of the site to the neighbouring residential area. RBC is well connected to the local core paths network. To the north of the site lies Killburn Wood, an area of semi-natural woodland which can be accessed directly from the northeast of the site and from the B7006 north of the site entrance (fig. 4.12a). Facing the site on the B7006 a footpath

extends west to the Gowkley Moss roundabout close to the Bush Estate (fig. 4.12b). There is also a footpath extending north-east from the south-east corner of the site.

Figure 4.11a-f: Roslin BioCentre open space

a

b

c

d

e

f

Figure 4.12a,b: Roslin BioCentre footpath links to wider area

a

b

Planning context

Like PSP, the RBC site is covered by the Edinburgh and Lothians Structure Plan 2015 and Midlothian Local Plan, with the local plan proposal RP3 (major established green belt uses) also applying to the site of RBC and formerly the Roslin Institute. The site forms part of the local plan's established economic land supply, however the future of RBC at the site is now uncertain since the relocation of the Roslin Institute. In late 2012 a request was submitted to Midlothian Council for pre-application advice and EIA Screening Opinion for redevelopment of the site for residential use; it is proposed that this would include the demolition of the two RBC buildings as well as the former Roslin Institute to make way for 200 housing units (Midlothian Council 2012).

4.5.4 Stirling University Innovation Park

Location

Stirling University Innovation Park (SUIP) is located to the south of the Stirling University campus. The campus itself lies north of Stirling, around 500 m north-east of Bridge of Allan. SUIP can be accessed directly from the B998, and from the A9 via the university campus. Figure 4.13 shows the site plan, with an aerial view of the site shown in figure 4.14.

Background

The early phases of SUIP's development took place in the early-mid 1990s, with the most recent development completed in 2001. The property on the site consists of the single-storey Alpha Centre and Beta Centre, the two-storey Scion House, and the two-storey Logan Court to the west of the site. There is also a purpose-built laboratory

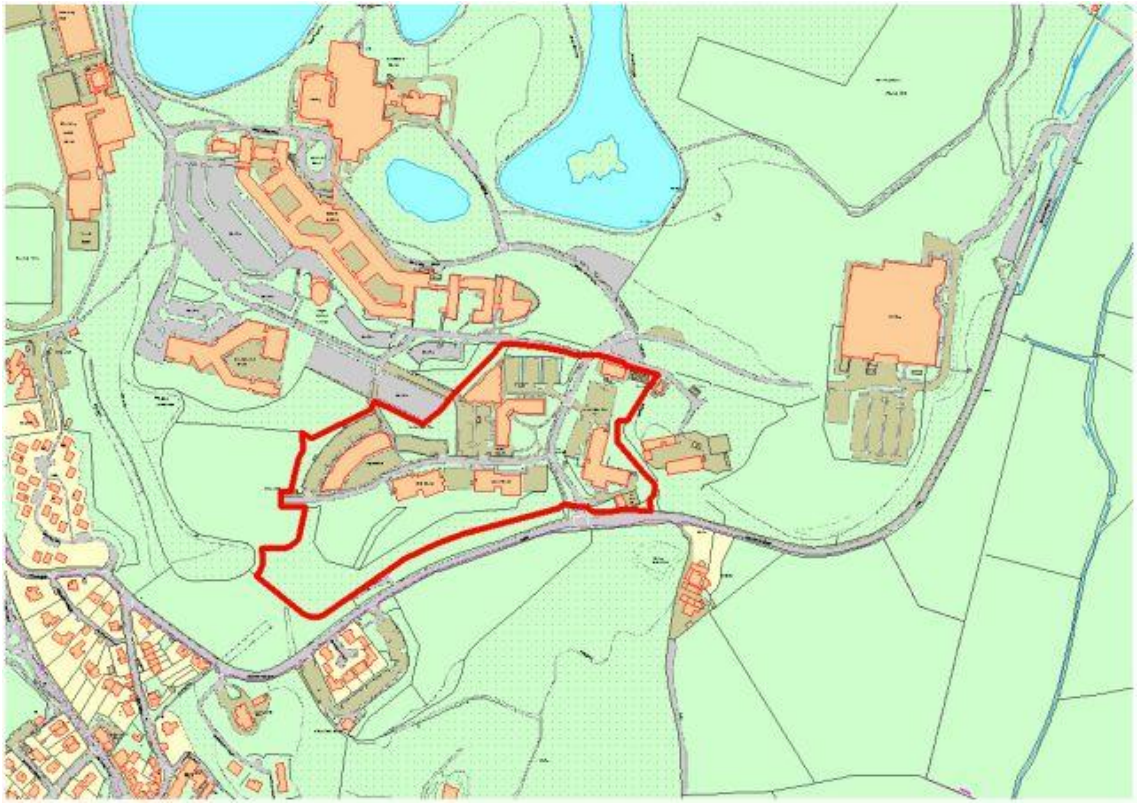

Figure 4.13: Stirling University Innovation Park site plan © Ordnance Survey.

Figure 4.14: Stirling University Innovation Park aerial view © Bing maps.

facility to the east of the site entrance from the B998. The development on site was funded by a variety of private and public sector partners and occupies around 5.5 Ha of the 121 Ha university campus (UKSPA undated-b). There are 33 tenant companies at the park (plus a number of single-person university spin-outs), with a total of around 425 individuals employed on site (as at February 2011). Key sectors at SUIP are environmental services/technology/heritage, people-centred healthcare, and sports technology, though the tenants overall represent a variety of knowledge-based industries.

Open space characteristics

The open space at SUIP consists primarily of amenity grassland and verges, shrub and hedge planting, and some mature trees (see fig 4.15). There are also unmown grassland areas to the south and west of the Alpha and Beta Centres (fig. 4.15f). The site has an open aspect, with views to the Wallace Monument directly south of the site (fig. 4.15b) and views of the more distant Ochil Hills to the north. There are several areas of seating close to the buildings, with a bench and picnic tables provided in the central area of the site to the front of Scion House (fig 4.15a) and other seating and picnic benches provided by tenant companies at exits to other buildings/units.

Figure 4.15a-f: Stirling University Innovation Park open space

a

b

c

d

e

f

Setting and neighbouring land uses

The open space on the university campus (formerly the Airthrey Estate) consists of extensive parkland with a large central loch crossed by a footbridge (see fig. 4.16a-c), and a golf course to the north-east of the campus at Airthrey Castle. To the west of SUIP is an undeveloped meadow area leading to a semi-natural wooded promontory (fig. 4.16d). To the south of the site is Abbey Craig, the wooded hill on which the Wallace Monument stands. Other neighbouring land uses are primarily agricultural, with residential areas lying to the south-east and north-east of the university campus.

Figure 4.16a-d: Open space at Stirling University campus

a b

c d

Planning context

The existing development plan applying to SUIP and the wider Stirling University Campus is consists of the Clackmannanshire and Stirling Structure Plan (2002, altered 2004) and the Stirling Local Plan (adopted 1999 and altered in 2007). These will be replaced by the Stirling Local Development Plan for which a proposed plan was published in late 2012. Under the existing structure plan SUIP is identified as an existing Strategic Employment Site (under proposal EDP1), and this is reflected in policy ED1 of the local plan alteration 1A which supports development at SUIP for

research and development (including ancillary uses). The Stirling University campus and SUIP are excluded from green belt designation in the local plan, however it is noted that the campus is an Area of Great Landscape Value (AGLV) and Historic Designed Landscape (listed in Historic Scotland's Inventory of Gardens and Designed Landscapes) so development should be sensitive to these designations. The proposed LDP allocates sites for future development to the west and east of the existing developed area of SUIP as Strategic Development Areas for employment use (with appropriate uses including class 4 business and in particular research and development relating to the University) and notes that development should preserve the designed landscape, Green Network and the setting of the scheduled Wallace Monument.

4.5.5 West of Scotland Science Park

Location

West of Scotland Science Park (WSSP) is located north-west of Glasgow city centre, around 1 km north-west of the Maryhill railway station. The development consists of two campuses lying on either side of the A81 (Maryhill Road); the original Kelvin Campus to the south-west of the A81 and the more recently developed Todd Campus to the north-east (see site plan in figure 4.17). The development lies at the apex of a green wedge extending in to the city from the north. An aerial view of WSSP is shown in figure 4.18.

Background

WSSP is a joint venture between the University of Glasgow, University of Strathclyde and Scottish Enterprise. WSSP opened in 1983 at the Kelvin Campus, where the land is held on long-term lease from the University of Glasgow (UKSPA undated-c). The Kelvin Campus shares the University's Garscube Campus, with the university sports facilities directly adjacent to the Kelvin Campus and its Wolfson Hall residences situated within the campus itself. The property managed as WSSP at the Kelvin Campus consists of nine pavilions of varying ages and designs, the most recently completed being the Venture Building which lies at the entrance to the Kelvin Campus. Whereas at the Kelvin Campus the property consists primarily of units in multiple occupancy buildings, the Todd Campus is to a larger extent composed of single-user buildings, most of which are a larger scale to those at the Kelvin Campus. The land at the Todd Campus is owned by a partnership between Scottish Enterprise and a number of private-sector organisations, and development on this part of the site consists of 14

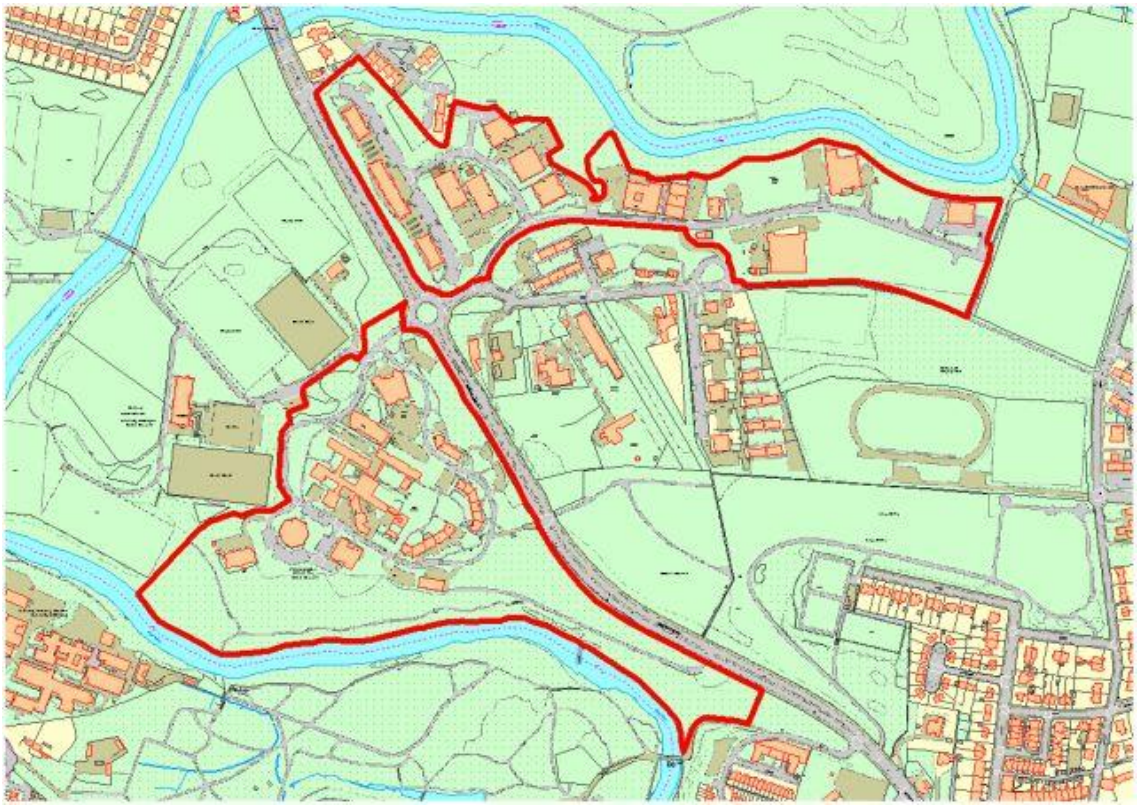

Figure 4.17: West of Scotland Science Park site plan © Ordnance Survey.

Figure 4.18: West of Scotland Science Park aerial view © Bing maps.

buildings, with undeveloped plots remaining available to the east of the site. In total, WSSP covers an area of around 25 hectares (UKSPA undated-c), with around 860 individuals from 35 companies based at the site as at June 2011. Key sectors at WSSP include electronics, software development and clinical research.

Open space characteristics

The character of the open space at the Kelvin and Todd Campuses differs somewhat due to the variations in building density and scale and the extent and level of establishment of the vegetation types present in the two areas of WSSP. The Kelvin Campus has a more enclosed character due to the mature broadleaved woodland surrounding the site (see fig. 4.19), however the adjacent open space of the University of Glasgow Garscube Campus has more open aspects across its sports grounds (fig. 4.19d) and open space bordering the River Kelvin to the west. There is an extensive area of semi-natural

Figure 4.19a-f: Open space at West of Scotland Science Park - Kelvin Campus

a b c d e f

woodland to the south and south-east of the Kelvin Campus. The woodland is served by a path network for pedestrian access, parts of which offer views overlooking the River Kelvin to the south. A pedestrian and cycle path through the woodland to the south-east of the site (fig 4.19f) links the Kelvin Campus to the nearby residential area of Maryhill and active travel routes along the River Kelvin to the city centre.

Figure 4.20a-f: Open space at West of Scotland Science Park - Todd Campus

a b c d e f

The Todd Campus has a more open character due to the relatively lower density development form (with several undeveloped lots to the east of the site). Car parking on the Todd Campus is more extensive and prominent than the Kelvin Campus and landscaping somewhat less varied, with mown grass predominating and less tree cover, particularly in the more recently developed eastern area of the site (fig. 4.20e,f) where the vacant plots of rough meadow provide a contrast to the formal landscaped open space at the site entrance (fig. 4.20a,b). A dense woodland buffer lies between the Todd Campus and the River Kelvin to the north. It is not clear the extent to which this area of woodland and the river beyond can be accessed from the lots at the north of the site, and there are no formal access points to this open space visible from the access roads on the site.

Setting and neighbouring land uses

The setting of WSSP is more urban than the other study sites. There are significant areas of recreational open space around WSSP: the Garscube Campus sports facilities to the north-west and woodland to the south and east of the Kelvin Campus; further recreation grounds and an urban park to the south east of the Todd Campus; the River Kelvin winding its way around the northern, western, and southern sides of WSSP as a whole. Beyond these open spaces, however, urban areas dominate on all sides of WSSP except to the north-east where a golf course and agricultural land uses comprise the green wedge extending from the north into the city of Glasgow. There are residential areas directly adjacent to the Todd Campus at its north-west and south-east. Other neighbouring land uses relate to education and research at the University of Glasgow to the west of the Kelvin Campus (including buildings on the opposite side of the river) and to the south of the Todd Campus (a smaller area of facilities including the University's observatory and wind tunnel).

Planning context

The Glasgow and the Clyde Valley Strategic Development Plan, approved in 2012, identifies WSSP as a Strategic Economic Investment Location safeguarded for life sciences/green technologies. Strategy Support Measure 3 of the plan requires LDPs to put in place measures to 'safeguard current locations and to ensure their ability to respond to their defined role and function'. The current local plan City Plan 2 (adopted in 2009) allocates WSSP as a Strategic Industrial and Business Area under Policy IB 2. This allocation includes the current WSSP site and extends to land currently under

agricultural and equestrian uses (with accompanying stables) to the east of the Todd Campus. Environmental designations also apply to the site and surrounds; the Kelvin Campus and associated Garscube Campus are designated as a Site of Special Landscape Importance (SSLI), and Green Corridor designation applies to the banks of the River Kelvin and its associated woodland at the site, ,and other public open spaces to the south-west of the Todd Campus. Under Policy ENV 7 of the local plan development proposals 'should not have an adverse effect, either directly or indirectly, on the integrity or character of one or more the natural, or special, features covered by an environmental designation'.

4.6 Concluding remarks

It is clear from the planning policies presented in this chapter that the provision and support of science parks is considered a priority for promoting knowledge-based industries in Scotland, particularly the key sectors of life sciences, electronics and other technologies. The drive to build Scotland's knowledge economy, in line with global economic transition, has over the last four decades led to a proliferation in urban-fringe science parks, particularly in the Central Belt. This type of workplace has unique properties which make the science park an ideal context in which to explore the impact of workplace greenspace on employee wellbeing. Knowledge intensive work poses a drain on attentional resources, so these workers may be at an increased risk of experiencing mental fatigue. At the same time, the productivity of knowledge sector companies relies on the effective functioning of employees and therefore the opportunities for restoration and recovery in greenspace that the urban-fringe campus environment presents may be of great value not just for employees but also businesses.

On the other hand, the science park landscape has been criticised by some as being overdeveloped and uniform 'non-places'; not descriptions we would naturally associate with restorative environments. Through a case study approach, this research investigates the influence of science park open space on the wellbeing of workers at five Central Belt sites and explores, through their experiences, meanings and perceptions, the presence of these potentially conflicting perspectives on the science park landscape. The next chapter (Methods) sets out how this was achieved.

Chapter 5: Methods

5.1 Introduction

This chapter details the research methods adopted in the study. Section 5.2 begins by explaining the overarching mixed methods approach and the rationale for the selection of each of the methods of inquiry. This is followed by separate descriptions of the quantitative and qualitative components in sections 5.3 and 5.4 respectively.

5.2 Mixed method strategy

The overarching aim of the project was to investigate the restorative value of science park open space and the potential wellbeing benefits that views and use of the open space may offer employees. Restorative effects of green space are primarily investigated using quantitative methods, as described in the literature review. This is the case in the investigation of both discrete restorative experiences and of cumulative benefits to wellbeing. Discrete instances of restoration have been measured: a) objectively using physiological and/or cognitive indicators and b) using measures of subjective perceptions and experience derived from self-report rating scales. The potential cumulative psychological effects of exposure to greenspace tend to be investigated using ecological approaches where statistical associations between variables (often derived from cross-sectional surveys) are tested. These methods are suited to generating robust quantitative evidence on the extent of impacts of greenspace on wellbeing. They are, however, limited in terms of what they can tell us about the lived experience of restoration in particular open spaces and how this varies spatially within a particular site. This sort of data, best captured using qualitative methods, could allow greater insight into the nuances of the experience in greenspace and the conditions that promote restoration, with implications for the planning and design of workplace greenspace.

With these considerations in mind, it was decided that a mixed methods research design incorporating both quantitative and qualitative methods was appropriate for this study. The epistemological status of mixed method approaches transcending qualitative and quantitative paradigms has been subject to much debate in the social sciences (Onwuegbuzie and Leech 2005). Quantitative methods have traditionally been associated with positivist epistemologies which view social research as analogous to the natural sciences, where researchers view themselves as detached from the subject of the

research and thus seek to make knowledge claims that reflect an objective reality of the world *as it is*. Qualitative methods, on the other hand, have been associated with interpretivist perspectives which contend that reality is subjective and constructed and so a multitude of realities exist in relation to any given social phenomenon. From the interpretivist perspective, a researcher cannot objectively 'observe', but must rather recognise that their own assumptions and methods of inquiry shape the knowledge claims that result from the research. Because of this ontological dualism, it has been argued that quantitative and qualitative approaches are incommensurable (Burke Johnson and Onwuegbuzie 2004, Onwuegbuzie and Leech 2005). However, many contributors to this debate reject this contention, arguing that this polarising perspective stifles progress in social enquiry. Pragmatism offers an alternative epistemological worldview - it challenges the idea that quantitative and qualitative approaches are necessarily tied to these opposing ontologies, viewing the terms quantitative and qualitative as descriptions of types of data rather than epistemologies (Mertens 2012). Pragmatism therefore allows room for acknowledgement that quantitative research is rarely value-free; that the research process is inherently subjective (e.g. in the decisions made with regards to research questions, instruments of measurement and interpretations). It also allows for qualitative research to consider the multiple realities of the interpretivist as different perspectives or beliefs relating to real-world phenomena (Burke Johnson and Onwuegbuzie 2004). By considering the strengths and limitations of quantitative and qualitative methods with respect to specific research questions, the pragmatic worldview therefore emphasises a focus on 'what works' to address the research problem at hand (Tashakkori and Teddlie 1998).

In the present study, a quantitative survey method was employed to investigate aspects of employees' relationship with Science Park open space (use and factors affecting use, broad perceptions and attitudes to the open space and views from the workplace), self-reported restoration outcomes, and cumulative effects of exposure to the workplace greenspace on the wellbeing of employees. The survey method is discussed further in section 5.3. A smaller qualitative study was also conducted to add depth and texture to the understanding of employees' relationships with the open space from the findings of the survey and, importantly, to explore aspects of their lived experience in the space and the meanings attached to it. The qualitative study consisted of in situ walking interviews with Science Park employees, and is discussed in section 5.4. Figure 5.1 below sets out the relationship between the methods used and the project objectives they address.

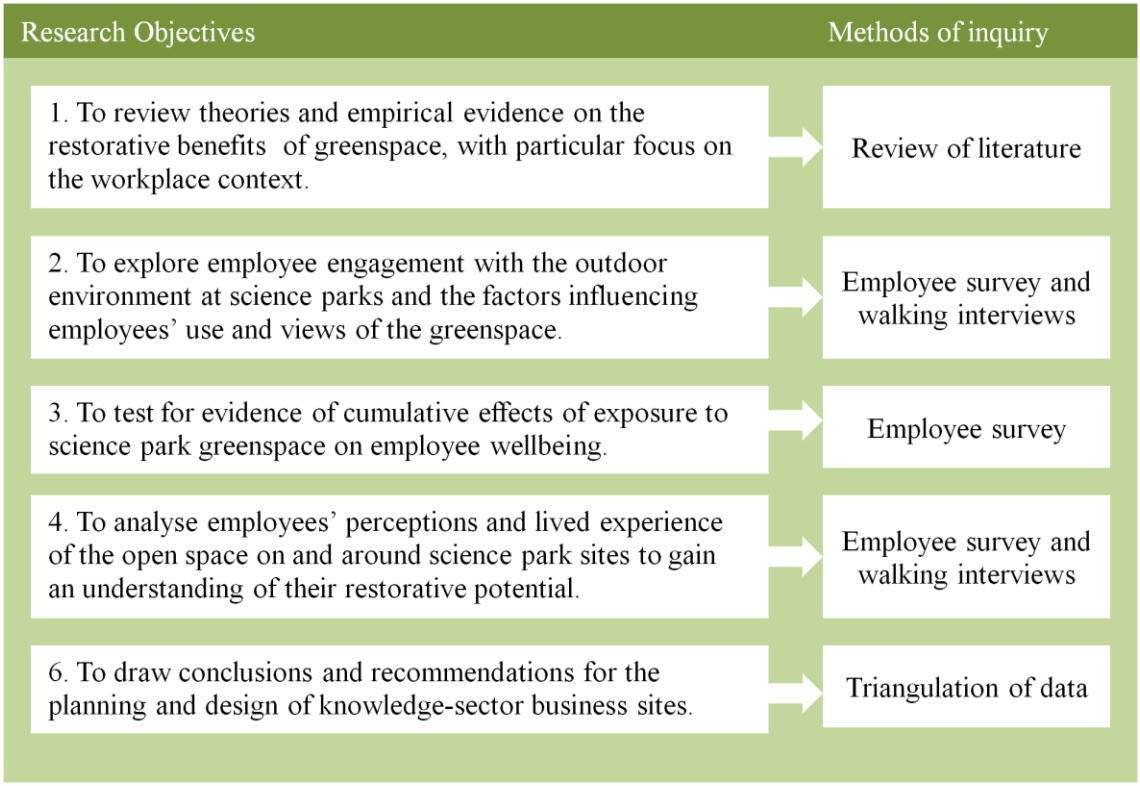

Figure 5.1: Data collection methods as relating to project research objectives.

Data collection took a sequential approach, with the survey data gathered from June to early September 2011 and the walking interviews conducted soon afterwards in late September and October of the same year. Although applying the different methods sequentially was advantageous in that it allowed the survey data to inform the development of the interview schedule, there were also practical reasons for doing so; it was intended that the interview participants would be recruited through the survey itself.

Initial intentions were to incorporate an additional element to the research involving a photo-based study where a sample of university students would view a series of photographs of each case study site and rate their restorative potential using a version of the Perceived Restorativeness Scale (PRS). This methodology was piloted but was rejected due to misgivings about the meaningfulness of single PRS scores to represent large heterogeneous sites, and because of an inherent tension between the use of student participants and the ecological basis of the overall case study design.

The following sections present the details of the employee survey (section 5.3) and the walking interview (section 5.4) methods.

5.3 Employee survey

5.3.1 Aims and rationale for method selection

As shown in table 5.1, the objectives of the project included: exploration of how employees' engage with and relate to the open space on the case study sites, in terms of both use and views (objective 2); testing for evidence of cumulative wellbeing benefits from exposure to the greenspace (objective 3); and to analyse perceptions and experiences of the open space (objective 4). In order to carry out objective 3 it was necessary for quantitative data be collected to allow rigorous statistical analysis of the complex relationship between outdoor environments and wellbeing. A quantitative approach was also desirable to address objectives 2 and 4, to gain an overall view of engagement with the open space and sources of variation in this respect, and employee perceptions of the quality and restorative potential of the environment.

Employing a questionnaire survey method allowed for this varied data to be collected using a single method, minimising the time-burden on organisations and individuals. The time required for employee participation proved to be crucial in negotiating access with organisational gatekeepers. Other methods may have addressed certain elements within the three objectives listed above, but would have been neither sufficient nor practical. For example, structured (non-participant) observation is often used to investigate behaviour in open space, including use levels and practices (see Ward Thompson and Travlou 2007, Ward Thompson et al. 2010), however individual-level data on use was required to address objective 3 (cumulative benefits) and various practical constraints also rendered this option undesirable. Other studies have incorporated objective measures of restoration outcomes (see section 2.2), however to do so would require a level of experimental control that was not possible here. For example, random sampling of subjects, control of treatment conditions, and/or group interventions were not feasible due to the constraints inherent in working with a population of employees during their working hours, relying on the goodwill of organisations.

Self-completion questionnaires are a useful research instrument as they facilitate standardisation in the way that data is collected, which allows valid statistical comparisons and testing to be performed, and at the same time are relatively quick and cheap to administer (Bryman 2008). In this project there were other practical benefits; this was the simplest and most effective way to access a wide range of employees on

each site as it provided a way for individuals to respond at their own convenience, without demanding a great deal of effort and time.

There are, however, various limitations that questionnaire surveys may be vulnerable to. Respondents are not able to ask for clarification when questionnaires are self-administered, which means that the precise wording and pre-testing of questionnaires is paramount. Similarly, the researcher is not able to prompt or probe for further detail in the responses given. Another practical limitation is that the length of the questionnaire and number of questions must be limited to avoid respondent fatigue (Bryman 2008).

There are also limitations inherent to self-report data as it opens up a potential for bias through conscious or unconscious manipulation by respondents. The possibility of social desirability bias (where responses are influenced by considerations of how they might be judged by others) cannot be ruled out. In addition, with organisational studies or others like this research where access is gained through employers there is a concern that some respondents might feel under pressure to adapt their response (e.g. avoiding criticising elements of their workplace or reporting low job satisfaction) if they have concerns about being identified by their employer or are worried that negative comments (even when anonymised) could reflect negatively on their organisation (Donaldson and Grant-Vallone 2002). Efforts have been made to mitigate this by maintaining the full anonymity of both the respondents and participating organisations.

Also due to the cross-sectional nature of one-off questionnaire surveys the extent to which temporal variation and issues of causation can be investigated are limited. The questionnaire used in the study attempts to capture temporal dimensions of use in that it asks respondents to indicate use levels during both the summer and winter months. It is acknowledged, however, that the accuracy of these measures may be influenced by respondents' memory and interpretations. As the survey was administered during summer, respondents had to make a judgement from memory on their winter use levels. The previous winter (2010-2011) had been particularly inclement; December 2010 was the coldest month recorded in Scotland since 1947 and heavy snowfall occurred during November to January (Met Office 2011). It is possible that some respondents used that period as a frame of reference whilst others may have responded in terms of what they considered to be an 'average' winter.

Finally, Bryman warns that self-completion questionnaires are vulnerable to low response rates and 'unless it can be proven that those who do not participate do not

differ from those who do, there is likely to be the risk of bias' (Bryman, 2012:235). The nature of the survey sample is discussed in the following section.

5.3.2 Sample and Access

Access to the study site communities was gained through a three-stage process. First access to the sites for use as case studies was secured through meetings with the science parks' management. The next stage was to negotiate access to organisations located on the sites. A small number volunteered their participation directly after having been made aware of the project by science park managers; the remaining organisations were contacted through a mix of emails, letters and phone calls. Contacts were supplied by science park managers at four of the five sites, and in the remaining site contact names were gathered through telephone enquiries, using an up-to-date list of organisations available online. Initially enquiries were made by email and phone calls. However it became clear at a relatively early stage that due to the number of non-responses to emails and difficulties gaining direct access to the appropriate managers by phone, an alternative strategy should be sought. Henceforth, personalised letters were sent to named contacts (see Appendix A). These were countersigned by a professor and enclosed a response form and pre-paid envelope. Follow up phone calls were made where necessary. In the third stage, key contacts (gatekeepers or their nominee) forwarded group emails inviting staff to participate in the survey. The implementation of the survey itself is discussed further in section 5.3.4.

A total of 366 responses (345 complete) from staff at 82 organisations were received. Participating organisations ranged from small start up businesses with a single employee up to regional offices of multinational companies and offices of national public sector organisations. A breakdown of responses by site shows that the sample size at each site varied widely (see table 5.1). Of the 345 respondents who completed the survey 56.2% were female, 42.9% male and 0.9% (3 respondents) declined to state their gender.

It was not possible to employ a probability sampling strategy in the survey. To achieve a random sample from the target population would have required access to a list of the individuals working on study sites to serve as a sampling frame (Bryman 1989). Initially, a cluster sampling method was considered as an alternative; this would involve treating organisations as clusters, with a number of clusters selected at random to be invited to participate. It was, however, unclear as to whether this procedure would

Table 5.1: Responses by study site

Site	Participating organisations	Total no. of staff[1]	No. of responses[2]	Estimated response rate (%)
Heriot-Watt University Research Park	18	455	134	29.5
Pentlands Science Park	10	227	73	32.2
Roslin BioCentre	13	62	24	38.7
Stirling University Innovation Park	23	215	92	42.8
West of Scotland Science Park	18	205	43	21.0
All sites	82	1164	366	31.4

[1] Estimates supplied by organisational contacts
[2] Partial responses included

result in a large enough sample size to allow meaningful statistical analysis. Since the size of organisations varied greatly across and within sites (ranging from one sole member of staff up to around 250), random selection of organisations had the potential to result in vastly differing sample sizes. Both the risk of: a) problems in gaining access to organisations to participate in a study not directly connected to their area of business expertise; and b) low response rates within participating organisations were considered key risk factors which could compromise the research. It was due to these concerns that the initial intention to employ an element of random sampling was discounted and the decision made to approach all organisations, and to invite all staff at participating organisations to take part in the survey. These kinds of practical constraints on sampling are common in social research within an organizational context, and Bryman (1989:115) noted a 'widespread recognition among organizational researchers that investigations using sample surveys are rarely based on probability samples'. A key issue to note here is that although the sample was not randomly selected, all employees within the participating organisations were given an equal opportunity to participate.

Perhaps a more fundamental concern about the sample was the risk of non-response bias. The overall response rate to the survey was 31.4%, which varied between sites, ranging from 21.0% (at WSSP) to 42.8% (at SUIP). Non-response presents a limitation to the accuracy of findings when there is evidence of a systematic bias in responding i.e. where those that respond differ in a meaningful way from those that do not (Bryman 2008). As no profile of the target population was available it was not possible to comment on the representativeness of the sample with regards to demographic factors. In this research it was expected that those with greater interest in environmental issues, particularly greenspace and nature, would be more likely to respond and at the same time might be expected to be more likely to both use the open

space and to benefit positively from exposure to nature. To assess the presence of a systematic bias of this nature in the *de facto* sample, working in organisations whose focus is on environmental management was used as the only available proxy for environmental interest. The proportion of respondents working in such organisations was compared to the estimated proportion of the population at each site doing so (using estimates of staff numbers supplied by site managers) and found evidence that environmental sector staff were somewhat over-represented in the sample (see figure 5.2).

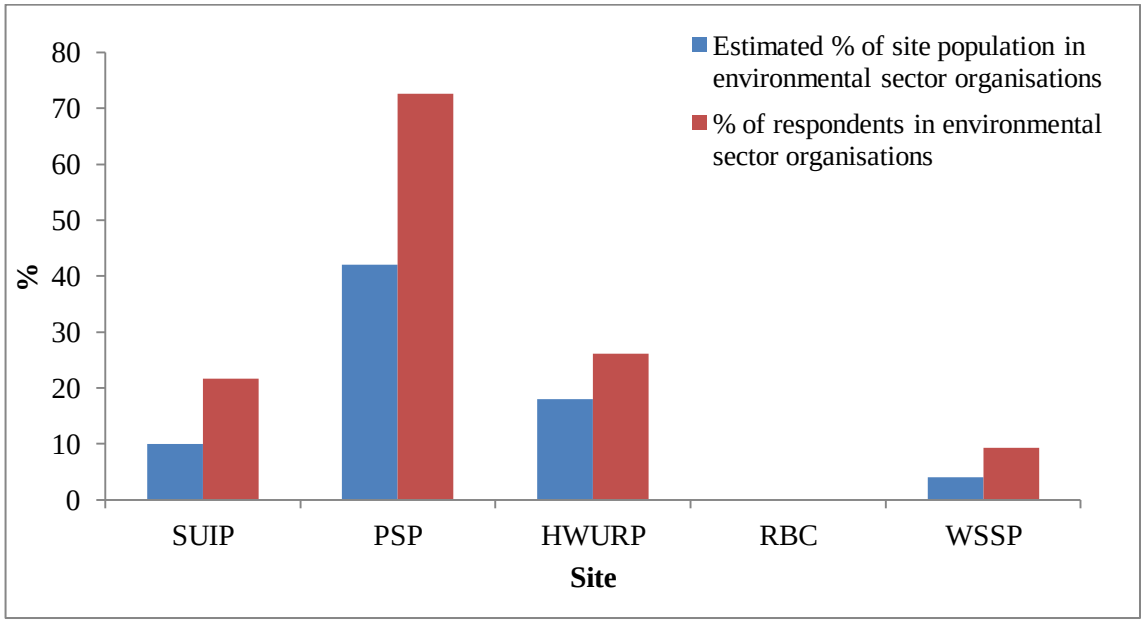

Figure 5.2: Representation of environmental sector workers in the survey sample as compared to the study sites' populations.

To take account of this apparent self-selection bias in the sample, the differences between these two sub-groups - environmental sector workers and others - have been explored in the statistical analysis presented in chapters 6, 7 and 8. Recognising this over-representation of environmental sector workers in the sample has therefore allowed this apparent selection bias to be taken into account in analysis and interpretation of the survey findings.

5.3.3 Questionnaire design

The survey questionnaire was designed through an iterative process of drafting, pre-testing, refinement, piloting, further refinement and final testing, as recommended by various authorities on social research methods (e.g.Bryman 2008, Dillman et al. 2009).

An early version of the paper format of the questionnaire was tested in a small focus group of four postgraduate research students. Revisions were made and tested further

by two further volunteers. A small pilot study was conducted with a sample of 39 office-based university staff (academic and administrative) and research students, using the web-based questionnaire. Following the pilot, further revisions were made and the final questionnaire again pre-tested by a small number of volunteers, including a member of the target population at one of the case study sites.

The final questionnaire (see Appendix C) comprised 40 questions, plus an additional item inviting respondents to submit contact details if willing to participate in an interview. The questionnaire was divided into five sections, each of which was presented on a separate web-page. These sections focused on: information about the work context; window views of the open space from indoors; use of the open space; attitudes and perceptions of the open space on site (including ratings of restorativeness); and finally wellbeing and background information (including demographics and exposure to greenspace outwith the workplace context). The majority were closed questions, utilising a variety of question formats such as multiple-choice items, Likert and Likert-type scales and items, and checklists. Where appropriate, scales or items already tried and tested in previous research were used so as to minimise measurement error and offer opportunities for comparison. A small number of open ended questions were also asked where very short text answers were desired (names of organisations and buildings), and for optional questions requesting descriptions of any favourite/disliked places, and any further comments on window views and desired changes to the open space. Questions asking for potentially sensitive information (wellbeing and job-related factors) were non-compulsory and were placed in the final section of the questionnaire in order to minimise attrition.

Primary view variables

Alongside the use of simple five point Likert-type items to gauge attitudes to views (ratings of satisfaction and importance) and ease of viewing out, two further questions focused on the actual content of respondents' views. One of these was designed to measure the 'naturalness' of the primary view, using a balanced seven point Likert-type scale representing a continuum of 'completely built' to completely natural'. A more complex multi-item Likert-type scale was designed to measure the extent of various feature types (e.g. trees, mown grass, buildings) in the window view (see question 12 in Appendix C).

Open space use variables

Four items were used to measure levels of use of the outdoor space around the workplace. Respondents were asked to report both use frequency (with seven response options offered, ranging from 'every day' to 'never') and use duration over the course of week (six response options from 'less than 15 minutes' to 'more than 5 hours'). Taking into account the expected seasonal variation in use levels, these questions were each asked in reference to both the summer and winter months separately.

The other main use variables drawn from the survey were motivations and barriers to use and social context of use. Data on motivations and barriers was gathered using checklists of options designed with reference to the literature, study objectives, and focus group/tester feedback (see questionnaire items 20 and 21). A question on social context of use determined whether respondents' time in the open space tends to be on their own or with others.

Measure of perceived restorativeness

The Restoration Outcome Scale (ROS) (Korpela et al. 2008, Korpela et al. 2010) was employed to measure the perception of discrete restorative benefits experienced as a result of using the open space. This six item self-report Likert-type scale contains statements describing restoration outcomes (e.g. 'I can forget everyday worries here') to which participants are asked to rate their level of agreement on a balanced 7-point scale (question 30). Three of the ROS items relate to relaxation and calmness, two relate to the clearing of thoughts, and the remaining item relates to the outcome of attention restoration (Korpela et al. 2008). In analysis the item response options were coded from 1 to 7, and a mean summary ROS score across the six items was calculated for each respondent.

This instrument was chosen over other measures of restorativeness, notably the widely applied Perceived Restorativeness Scale (PRS) (Hartig et al. 1997). The ROS was preferred for the purposes of this study due to reasons of brevity and face validity. The original four sub-scale, 16 item PRS (Hartig et al. 1997) and the adapted five sub-scale 29 item variation (Purcell et al. 2001) were considered to be too long for inclusion in the questionnaire due to concerns about participant burden. In terms of face validity, the PRS is grounded solely in Attention Restoration Theory (measuring perceptions of fascination, being away, compatibility and extent/coherence) whereas the ROS also draws on theories of stress reduction in natural environments and so represents both

elements of cognitive and psycho-physiological restoration. Also, the PRS focuses more on perceptions of particular qualities in the environment itself (e.g. fascination and coherence), rather than perceptions of experienced outcomes. As the sites in question were large and heterogeneous, participants may have had difficulty determining ratings for the site *as a whole*, which may have led to different respondents using different areas of the site as a frame of reference or to a greater central tendency in responses.

Wellbeing outcome measures

Three of the questionnaire items gathered information on the wellbeing-related outcomes of overall mental wellbeing, job satisfaction, and sickness absence levels. Job satisfaction (question 34) was measured using a single 5-point Likert-type item with response options ranging from 'very dissatisfied' to 'very satisfied'. Sickness absence (question 35) asked respondents to report the number of days of absence from work due to sickness, ill-health or stress in the last 6 months.

Overall wellbeing level was measured using the short-version Warwick-Edinburgh Mental Well-being Scale (SWEMWBS) (Stewart-Brown et al. 2009) . This 7 item scale involves respondents rating a series of statements (e.g. 'I've been thinking clearly', 'I've been feeling useful') on a 5-point scale from 'none of the time' to 'all of the time'. Overall scores are calculated by summing the item scores.

This scale (see question 36 in Appendix C) is a variation of the longer 14 item WEMWBS which serves as the Scottish Government's National Indicator of population wellbeing in the National Performance Framework (Scottish Government 2013a). The 14 item WEMWBS measure (Tennant et al. 2007) has been used in population surveys such as the Scottish Health Survey, the Health Survey for England, British Social Attitudes Survey, Northern Ireland's Continuous Household Survey, Health Education Population Survey, and National Child Development Study (UK Data Archive 2009, Scottish Government 2012c). The shorter 7 item SWEMWBS is included in Understanding Society, the new UK Household Longitudinal Study (McFall and Garrington 2011). As well as being a policy-relevant measure of wellbeing, WEMWBS draws on both hedonic (happiness and life satisfaction) and eudaimonic (functioning, relationships and agency) perspectives on wellbeing, suffers no ceiling or floor effects, and has been subject to cognitive and psychometric testing and cross-cultural validation (Tennant et al. 2007, Stewart-Brown et al. 2009, Stewart-Brown 2013).

The main advantage of using the 7 item SWEMWBS over the longer WEMWBS was the reduction of respondent burden – a key consideration given the wide scope of the survey and the need to strictly limit the time required to complete the questionnaire. In addition, SWEMWBS has the advantages of being strictly unidimensional, conforming to the Rasch measurement model of expected responses for ordinal scales, and published values are available for converting raw scores to interval-level scores (Stewart-Brown et al. 2009). SWEMWBS has also recently been used in other studies of greenspace impacts on wellbeing. Winson (2011) found a significant difference between social housing tenants in buildings with and without surrounding trees. SWEMWBS was positively associated with perceptions of local greenspace quantity, quality and safety in a recent study of residents of deprived urban areas in Scotland (Ward Thompson et al. 2013). However in a related study, although SWEMWBS scores were associated with stress levels, there was no significant association between greenspace availability and SWEMWBS (Ward Thompson et al. 2012, Roe et al. 2013). Although recent applications of the longer WEMWBS have found less evidence of relationships with greenspace use in the Scottish population (Mitchell 2012), WEMWBS has, on the other hand, been found to be sensitive to work-related factors like work demands, role, and social support (Bartram et al. 2011).

Background data

Questions were included to gather demographic data on gender, age and socio-economic coping. The latter (question 38), rather than measuring objective socio-economic factors through income or proxies such as educational level, employs a subjective rating of the how difficult the respondent finds it to cope on their household's current income. Variations of this question feature in large-scale surveys such as the both the Scottish and British Social Attitudes Surveys and the Scottish Household Survey (UK Data Archive 2009, Economic and Social Data Service 2010).

Several questions were incorporated primarily as control variables in regression modelling of associations between greenspace exposure and wellbeing. These included work demands (ratings of how stressful and how mentally demanding respondents find their work to be), other work factors (e.g. job type, working hours, length of time working on site, satisfaction with the indoor workplace environment), recent experience of stressful major life events, and opportunities for restoration in green environments in leisure time (whether respondent has a private garden, frequency of participation in outdoor activities such as walking, cycling, visiting parks etc.).

5.3.4 Implementation

Dillman's Tailored Design Method for survey research provides useful guidance on minimising survey error in the form of coverage error, sampling error, non-response error and measurement error through the application of a suite of complementary procedures designed to maximise the quantity and quality of responses (Dillman et al., 2009). Tailored Design applies social exchange theory to promote trust, and to encourage perceptions of increased rewards and reduced costs of responding to a survey e.g. through acknowledgement of institutional affiliation and sponsors (to promote perceptions of legitimacy); by making contact on multiple occasions; using personalised rather than generic communications materials; offering incentives; and giving assurances of confidentiality (Dillman et al. 2009). The principles of the Tailored Design Method guided decision-making on the implementation of the survey in particular, along with other sources of advice on strategies to maximise response rates (Groves et al. 1992, Bryman 2008, Edwards et al. 2010).

The online questionnaire was created using the LimeSurvey open source web survey application. This application allows survey designers to tailor the design, layout, and question formats as required, and offers the opportunity to pre-code response options and export responses in the form of Microsoft Excel and PASW Statistics files. It also gives respondents the option to save responses at any point and return later to complete the remaining questions. In order to promote perceptions of salience, a separate online questionnaire was created for each site, with the site name featuring in the title and in some of the questions. The questionnaires were identical in all other respects. The surveys were hosted on the School of the Built Environment's website.

There are both strengths and weaknesses associated with the use of the internet in administering surveys. The primary benefits of online surveys are the significant time and cost savings associated (Joinson et al. 2007, Dillman et al. 2009). Another strength is that online surveys may provide greater anonymity for respondents; compared to mail surveys, web surveys have been associated with reductions in social desirability responding and increased willingness to answer sensitive questions (Joinson et al. 2007). One of the main concerns relating to the use of web surveys is their potential to introduce coverage error, as those who have no internet access are excluded and there is a potential for the age profile of samples to be skewed towards younger respondents (Dillman et al. 2009, Hines et al. 2010). However, web surveys have been regarded as a useful and appropriate method for investigating particular populations such as company

employees who have regular internet access (Cook et al. 2000, Kaplowitz et al. 2004). As the population of interest in this study is desk-based knowledge economy workers (for whom email is a primary method of communication) the likelihood of a selection bias occurring due to the web-based nature of the survey was considered to be negligible. In general online/email surveys do tend to result in lower response rates than mail surveys (Kaplowitz et al. 2004, Shih and Fan 2008), however meta-analysis has found limited evidence of such an effect in the context of the workplace (Baruch and Holtom 2008).

Recruitment

Staff at participating organisations were invited to participate in the survey via an email invitation forwarded by the key contact at the organisation or their nominee (see Appendix B). These covering emails contained: a brief description of the aim of the study; the link to the survey online; an indication of the time required and an assurance of confidentiality; a statement of the sponsors and supporting organisations; and the contact details of the researcher. A more detailed information sheet was also attached; this incorporated the logos of the university and funding body and emphasised the purpose and value of the research, along with the anonymous nature of the survey (Appendix D). Up to two reminder emails were also distributed (dependent on the agreement of organisation contacts) at fortnightly intervals. Although it was not possible to personalise emails to the level of named recipients, organisations and sites were named specifically.

Although financial or in-kind incentives are often recommended as a strategy to boost survey response rates (Bryman 2008, Dillman et al. 2009) a decision was taken not to offer an incentive to participate. There were several reasons for this. Firstly, it was not clear that use of the project's limited financial resources to offer an incentive would constitute value for money; meta-analysis of organisational studies has indicated that in this context there is no evidence of a significant impact of incentives on response rates to individual-level surveys (Baruch and Holtom 2008). Secondly, it was considered that to do so could undermine anonymity since if, for example, entry into a prize-draw was offered this would require respondents to provide personal contact information. This was undesirable due to the sensitive nature of some of the information requested (e.g. on respondents' wellbeing, life events, job satisfaction and job demands, and income coping). Only those volunteering to take part in a later interview were asked for contact information which could identify them personally; this was at the respondents'

discretion and an assurance was given that this information would be stored separately from their survey response. Thirdly there was considerable scope to appeal to potential respondents' intrinsic values (such as helpfulness), as opposed to extrinsic values (such as self-interest - see below). Priming research participants with words relating to intrinsic 'benevolence values' has been found to increase helpfulness in terms of the time that volunteers are willing to commit to research (Maio et al. 2009).

Self-determination theory differentiates between intrinsic motivations for behaviour (derived from within the person or the activity itself) and extrinsic motivations (from external consequences such as punishments and rewards) (Ryan and Deci 2000). Sources of intrinsic motivation in this context could be greater willingness to help a student researcher (Dillman et al. 2009), respondents' personal interest in their environment and its impact on their health and that of colleagues, and positive responses to the opportunity to express opinions about their everyday environments (Zeisel 2006). To support these, email communications were carefully worded in the active voice to frame the invitation as a personal request from a student researcher, and maintained a site-specific focus. Some studies have actually found that providing incentives can have a negative effect on response rates (Cook et al. 2000, Wenemark et al. 2010). It has been suggested that one reason for this might be the psychological effect of extrinsic motivations 'crowding out' or undermining intrinsic ones (as proposed in Motivation Crowding Theory), suggesting that incentives may be less valuable, or even counterproductive, where intrinsic motivations like interest in the study play a significant part in the decision of whether to participate (Frey and Jegen 2001, Wenemark et al. 2010).

Advice on applying tailored design principles to implementing web surveys also recommends that contacts should be timed 'carefully and strategically…with the population in mind' (Dillman et al. 2009:298). With this in mind, communications were timed such that emails would be distributed to staff towards the end of the working week. It was considered that the opportunity to take a short time out from working to respond to the survey on a Friday afternoon (when many of the potential respondents' minds might be already turning towards the weekend) would increase the intrinsic motivation to take part and reduce the perceived costs of responding.

5.3.5 Analysis

Prior to analysis, the five individual case study datasets created by the survey software application were merged to create a single file. As the data were automatically pre-coded and entered into the dataset, human error in entering responses was averted. The data were checked for other errors; this included inspection of the range for each variable and the match between code labels and attached values, checks for outliers (applicable only to the interval-level sickness absence variable) and any visual indications of suspect reporting patterns. Missing data were coded so as to differentiate between missing values at the end of an incomplete questionnaire and questions that respondents had skipped, and response rates for individual items calculated. Overall values for the psychometric scales used were also calculated.

Analysis of the quantitative survey results was conducted using PASW Statistics v.18. In exploring employees' engagement with the open space (objective 2) and their perceptions and experiences (objective 4) a range of different statistical methods were applied, including descriptive statistics and cross-tabulations, testing for differences using non-parametric tests for ordinal data (e.g. Mann-Whitney U, Wilcoxon, and Kruskal-Wallis tests) and parametric tests for interval level data (T-tests and ANOVA). Regression modelling (binary logistic and multiple linear) was also used to answer some specific research questions under these objectives. The analysis testing for evidence of cumulative effects of exposure to science park greenspace (objective 3) comprised regression modelling only. Ordinary least squares (OLS) linear models, ordinal/ordered logit models, and binary logistic (logit) models were applied as appropriate to each of the three outcome variables of interest (positive wellbeing, job satisfaction and sickness absence). Greater detail on the procedures used in the statistical analysis is presented alongside the results in Chapters 6, 7 and 8.

5.4 Qualitative Study - Walking interviews

The qualitative element of this mixed-methods study of employees' relationships with the open space around Science Park workplaces consisted of semi-structured 'walking interviews' with a small number of participants at each of the five study sites.

5.4.1 Aims and rationale for selecting method

The aim of the qualitative study was to add depth to the findings of the employee survey and to examine dimensions of the person-environment relationship that could not be

captured well using quantitative methods. Qualitative methods were considered to be particularly appropriate for investigating how participants use the open space, how they feel during and after using it, and how the experience varies in different spaces in and around the study sites. The intention was for the qualitative element of the study to complement the quantitative survey, the latter being the primary mode of data collection.

Mobile forms of qualitative research are increasingly being adopted in studies of place (Jones et al. 2008, Hein et al. 2008, Skår 2010, Evans and Jones 2011). Whilst these methods are referred to using a variety of terms, in essence the common thread is that they are performed on the move rather than in a static location. In some cases mobile methods have been used to facilitate conversation on topics other than the space in which they are conducted in. Anderson (2004), for example used a mobile method he called 'bimbling' in a study investigating environmental activists attitudes to development. On the whole though, it is more common for mobile interviewing methods to be used in studies of people's experiences and practices in particular places and the meanings they attach to them. Such methods have been described as offering 'a unique means of obtaining contextually based information about how people experience their local world and the effects these experiences have on health and well-being' (Carpiano 2009:271). Although mobile methods are receiving increased interest from place researchers in recent years and are seen as being part of a 'new mobilities paradigm' in social research (Sheller and Urry 2006), the methods themselves are not new. Kevin Lynch, for example, used mobile interviewing as one of the multiple methods of inquiry in his studies of how people make sense of the urban environment, published in the seminal planning and urban design text *The Image of the City* (Lynch 1960).

The terminology used to describe mobile interview methods varies, with the terms 'go-along' and 'walking interview' used most commonly. These terms are often used interchangeably, however some researchers have emphasised subtle differences between the methods. Carpiano describes the 'go-along' method as 'interviewing a participant while receiving a tour of their neighbourhood or other local contexts. In this regard the researcher is "walked through" people's lived experiences of the neighbourhood' (Carpiano 2009:264). Other definitions of go-alongs are more restricted, presenting the go-along as more of a shadowing technique than a tour – "the researcher walks with interviewees as they *go about their daily routines*, asking them questions along the

way" (Evans and Jones 2011:850, emphasis added). Evans and Jones (2011) provide a useful typology in which go-alongs are classified as one type of technique within the broader spectrum of mobile interview methods. Within this framework walking interviews can encompass anything from this form of 'natural' go-along, or the less prescriptive 'participatory walking interviews' (both on the participant-led end of the spectrum) to walking tours or guided walks of places less familiar to the interviewee (researcher-led methods).

Some of the interviews conducted in this study may arguably have fallen under the stricter definition of the 'go-along' in that participants were accompanied on a route that they themselves walked regularly, however they may not have chosen to do so on that particular day if the interview were not scheduled. Also, in some cases the interviews were less reflective of the participants' normal practice, particularly where the open space was not often used. For these reasons, the more generic term 'walking interview' has been adopted here.

A review of the literature on mobile interviewing methods and studies using this type of method was conducted during the research design phase. This highlighted the potential value of using this method as opposed to a more conventional indoor interview. The specific strengths of walking interviews include:

- As a hybrid of field observation and interviewing, practices and perceptions can be explored in context, enabling participants to show rather than describe spaces and features (Kusenbach 2003, Carpiano 2009, Clark and Emmel 2010).
- Discussing place in situ elicits richer and more detailed accounts, and can prompt discussion and raise new questions (Hitchings and Jones 2004, Carpiano 2009, Evans and Jones 2011).
- Walking interviews can capture the embodied aspects of place experiences i.e. how the environment is experienced through bodily sensations. Accessing this multi-sensory dimension of nature experience has aided the understanding of relationships with place in previous studies using mobile methods in green space (Hein et al. 2008, Skår 2010).
- Participant-led walking interviews shift control of the interview towards the participant, avoiding the unbalanced power dynamic that can occur in conventional interview methods. This can help to build rapport and promote open exchange (Carpiano 2009, Skår 2010).

- It has been noted that walking interviews in natural environments seem able permit comfortable pauses in the conversation, giving participants time to think, reflect and consider (Hitchings and Jones 2004, Ross et al. 2008, Skår 2010).

There are a number of limitations of walking interviews which must also be taken into consideration. One of the main limitations is that those with poor health and/or mobility may be excluded from participation (Carpiano 2009, Evans and Jones 2011). Mobile methods may, however, in be a useful in studies of inclusive design e.g. evaluating urban accessibility for wheelchair users (Hein et al. 2008). None of the wider survey sample from which the interview participants were drawn had reported health or mobility issues as a constraint to their use of the open space so exclusivity was not a limitation in this case.

Breaking from the security of a mutually agreed indoor venue can also have implications for the personal safety of both parties. This may be a particular concern when the study context is high crime urban neighbourhoods (Carpiano 2009). The potential risk to personal safety was assessed as part of the formal fieldwork risk assessment process and was deemed to be low; the study sites each had security measures in place including CCTV, and other measures were taken by the researcher to minimise risk (such as carrying a mobile phone at all times, informing a contact before attending an interview and later confirming return).

The outdoor venue also means that data can be influenced by time of day and weather conditions, and on a practical level wind and other background noises can impact on the quality of audio-recordings (Carpiano 2009). In mobile interviews it is also important to be able to later connect words on an interview transcript to the spatial context in which they were said. When participants refer to features or spaces using vague language or gestures this can be difficult to analyse, so techniques such as inserting verbal cues into the dialogue, taking field notes, and recording routes are recommended (Jones et al. 2008, Clark and Emmel 2010). In selecting the interview method other options to situate interview data within its spatial context were considered, including participatory mapping and photo-elicitation methods (Clark-Ibáñez 2004, Emmel 2008). However, the unique strengths of the walking interview method made it preferable to indoor alternatives in principle, and pre-testing of audio equipment and piloting the method confirmed that those practical limitations that were pertinent to the study (e.g. challenges as a result of weather conditions, background noise and recording the spatial context) could be mitigated by the use of strategies recommended in the literature.

Overall, the walking interview method was considered ideally suited to studying person-environment relationships, and has been recommended particularly for exploring themes of environmental perception, spatial practices, biographies and social realms (Kusenbach 2003). The method shares similarities with user walkthroughs sometimes used in Post Occupancy Evaluation of buildings (e.g. Watson 2003, Kaya 2004).

5.4.2 Participants

Participants were drawn from volunteers who had responded to the online survey. The qualitative study was conceived as a secondary and supporting element to the employee survey, and as such the intention was not to aim to recruit a large number of participants. Sixteen employees were interviewed overall. This included a pilot interview which was carried out with a friend of the researcher who worked at one of the case study sites. The aims of the pilot interview were to practice the interview technique, test out the interview schedule and the performance of recording equipment outdoors, and to gain a better idea of how great a constraint the time period allotted (45 minutes) would pose. Since the participant in the pilot was also a member of the population of interest in the study the data collected was incorporated into the main qualitative study.

Methodologists generally advise that qualitative studies should include as many cases as is necessary to achieve data saturation (Bryman 2008, Baker and Edwards 2012). This principle is based in the grounded theory approach which recommends an iterative procedure whereby data collection and analysis take place concurrently as part of a non-linear process, and data collection ceases only at the point where no new theoretical insights continue to emerge (Glaser and Strauss 1967). A number of methodological studies have reported reaching theoretical saturation at around 12 to 17 cases (Guest et al. 2006, Francis et al. 2010), though of course in practice this depends heavily on the scope of the study and the homogeneity of participants (Baker and Edwards 2012). It was not within the scope of this project to conduct an exhaustive study applying a non-linear research process, for reasons of time, resources and also seasonality. The main aim of this supplementary qualitative study was to gain a snapshot of perceptions and experience of the open space, and as such data collection was concentrated within a little over one month, with analysis conducted post hoc. The aim was to avoid extending data collection across the seasons into the winter months as this would have necessarily increased the scope of the study and limited cross-comparisons between data from the interviews and the survey. At the point at which these sixteen interviews had

taken place there was evidence of data saturation with respect to key categories e.g. meanings attached to time spent in open space at workplace, psychological outcomes of the open space experience, how users' experiences map onto those described in theories of restorative environments, and users' broad reasons for choosing particular areas etc. However due to the limited number of interviews conducted within each study site it is likely that further sampling would have brought to light more detailed themes with regard to environmental and design features particular to each site. Therefore data-driven considerations were balanced against practical constraints to determine the final number of cases in the qualitative element of the study. A key issue in terms of sample sizes in qualitative research is that the conclusions drawn should not extend beyond those supported by the data (Baker and Edwards 2012). It is recognised here that the limited sample size has implications for the extent to which comparisons can be drawn between sites or between participant groups (e.g. by gender).

Participants were selected based on a number of criteria to maximise variation in the sample: gender, age, study site, organisational sector (whether environmental or not) and where appropriate the location of their workplace on the site. The sample was fairly balanced in terms of gender, included participants ranging in age (mid-twenties to early seventies), and covered all five sites. Three participants were selected at each study site, plus the additional pilot interview participant at HWURP. It was considered important for the research that interviewees should be drawn from all the study sites as this would allow a greater diversity of place types to be explored and would also allow comparisons of perceptions and experience of different environments of the same type e.g. woodland areas across different sites. Attempts were made also to select participants who worked in different buildings or different areas of the sites to maximise variation. The number of interview participants selected from organisations with an environmental management/protection/design focus was purposefully limited in order to access as wide a range of views as possible. At both HWURP and SUIP one of the three selected participants worked in environmental sector organisations. At PSP, where the largest occupant is an agricultural science institution, two of the three participants were involved in this type of work.

5.4.3 Timing of interviews

It was decided at an early stage in the research design phase that interviews would be carried out in the employees' own time rather than during their paid working hours, and because of this a £10 shopping voucher was offered as an incentive to take part.

Participants were informed in advance that interviews would last up to around 45 minutes (or longer if they wished) and could be conducted at a time convenient to them. It was felt that 45 minutes was appropriate as this could be more easily accommodated into lunch breaks than a longer duration. Most chose to use their lunch break to take part.

All interviews took place between mid-September and the end of October 2011. Weather conditions varied substantially, from warm and sunny to cold and wet or very windy. Participants were given the opportunity to cancel or postpone an arranged interview if they did not wish to go outdoors because of the weather at the time of their interview. Only one interview was postponed due to the weather.

5.4.4 Informed consent

Participants were supplied with an information sheet in advance of the interview which detailed the purpose, format, timing and duration of the interview, along with a statement on confidentiality and anonymity (Appendix E). Before interviews commenced participants were asked to read and sign a form (Appendix F) to confirm that they understood their rights as a participant and consented to take part in the study and for the interview to be audio-recorded.

5.4.5 Interview procedure and content

The interviews were semi-structured in nature, with an interview schedule used to guide the discussion (Appendix G). The content of the interview schedule covered attitudes to the window views from the workplace, use of the area around the building and the wider site and surrounds, perceptions and experience of the environment, workplace norms regarding use of the open space, and attitudes to having access to workplace greenspace. The schedule was not strongly adhered to, but rather used as a guide to ensure important topics were covered during the interview; it was considered more important to allow the participant to lead the direction of the conversation and retain an informal tone so as to put them at ease and encourage an open exchange.

Interviews commenced by discussing the area around the participants' building and their view of it from indoors. In many cases this also included discussion of any views from the area in the building that lunch breaks were taken (if away from their desk). The focus then moved to the wider site and surrounding area. The route walked was selected by the participant in all but one case. This participant (who did not tend to

walk in the open space) asked the researcher to suggest the route. The interviewees were encouraged to point out any features (including non-visual stimuli) on the way that they particularly appreciated, disliked or that otherwise held meaning for them. As the 45 minute mark approached participants were informed of this and asked if they would like to now head back to their workplace. In several cases the interviewee (particularly those who were self-employed or had flexible working hours) chose to extend the interview rather than return to work immediately.

The conversation was recorded on a portable audio recorder, using a microphone with windshield attached to the participant's clothing. Where appropriate during the interview, verbal cues as to the current location or environment were incorporated into the conversation and immediately after each interview the route walked was recorded on a map, noting also points where we stopped to discuss a particular area, notable feature or view.

5.4.6 Analysis

The data were analysed using thematic analysis. Although some have argued that thematic analysis is a tool that is used within particular overarching qualitative approaches or traditions, it can also be viewed as a method in and of itself (Braun and Clarke 2006). Thematic analysis was considered to be an appropriate analytical approach given the modest scope of the qualitative study as a secondary element within the wider research project. Alternatives that may have been appropriate for the topic of the research - such as a grounded theory approach (Glaser and Strauss 1967, Strauss and Corbin 1990) or interpretative phenomenological analysis (Smith and Osborn 2003) - were not considered appropriate for the aim and scope of the qualitative study, since inductive theory development was not the purpose of the study, and the limited scope did not allow analysis and reporting of participants' experiences at the depth required by a phenomenological approach. The 'theoretical freedom' (Braun and Clarke 2006) afforded by thematic analysis was also considered an advantage, in-keeping with the pragmatic epistemological approach to the research. This quality of thematic analysis allows the qualitative research to sit comfortably alongside the quantitative research within this mixed methods project, avoiding any tensions in integration that adherence to a purely constructionist epistemology, for example, would have created.

The process of thematic analysis followed six steps outlined by Braun and Clarke (2006): 1) getting familiar with the data, including through transcription of verbal data;

2) generating initial codes; 3) searching for themes; 4) reviewing the themes; 5) defining and naming themes; 6) producing the report. The data were coded and themes analysed using NVivo v.10 computer-assisted qualitative data analysis software. Some of the themes identified in the data were arrived at through consideration of the data in relation to the established theories of restorative environments, others drawn from broad categories determined by the interview schedule, and further categories and themes arose inductively during analysis.

5.5 Concluding remarks

This chapter has set out the rationale for and implementation of the methods used in the research. Within the overall mixed-method approach, both quantitative and qualitative approaches were adopted. The quantitative data, collected through the online employee survey, addresses questions regarding employees' use and visual access to the open space (objective 2), the cumulative effects of these exposures (objective 3), and the nature of employees perceptions and experience of the open space (objective 4). The qualitative data, collected through the walking interviews, was used to further explore aspects of the objective 2 and 4. The following chapters address these three objectives separately, integrating the quantitative and qualitative findings where appropriate. Chapter 6 focuses on engagement with the open space and the factors influencing visual access and use. Chapter 7 goes on to explore relationships between these forms of exposure to workplace greenspace and various aspects of wellbeing, in order to understand the potential for cumulative impacts on employee wellbeing. Chapter 8 focuses in more closely on workers' everyday experiences and perceptions of the open space, including discrete instances of restoration in these environments. Throughout the presentation of these results, the implications for planning and design are highlighted (in relation to objective 5), and these are consolidated in the conclusions presented in Chapter 9.

Chapter 6: Employee engagement with science park greenspace

6.1 Introduction

This chapter explores how individuals based on the study site science parks engage with the open space, and the factors influencing use and views of greenspace in the workplace context. Employees' opportunities for visual access to the greenspace are described briefly in section 6.3. Section 6.4 then goes on to explore the extent to which these workplace open spaces are used in both summer and winter. The focus of the rest of the chapter is on analysing the factors influencing use of the space – section 6.5 presents the results of models predicting self-reported use levels, with sections 6.6 and 6.7 discussing the various motivations and barriers reported by workers. Much of the analysis presented in this chapter draws on data from the employee survey, with qualitative analysis of the walking interviews providing greater depth. The discussion of stated motivations and barriers to use of the open space draws heavily on the qualitative analysis. The greatest part of the chapter focuses on use rather than visual access; whereas visual access was largely determined by building design and interiors, outdoor use depended on a wide range of factors influencing individual practices, including many aspects of the open space design.

6.2 Survey sample characteristics

Overall there were 366 responses to the online survey received, 345 of which were completed through to submission (and had therefore reached the final section gathering demographic data). Table 6.1 shows how the sample was split on a number of key factors.

There was a reasonably even gender split, with somewhat more women than men in the sample. The majority of respondents were aged between 25 and 54, with only 3% below the age of 25. All of the four job type categories were well represented, with the greatest proportion (40%) working in technical/professional roles. The sample size at each of the case study sites varied from 24 respondents at Roslin BioCentre to 134 at Heriot-Watt University Research Park. This disparity places some limitations on between-site comparisons and the interpretation of differences.

Table 6.1: Survey sample characteristics

Factor	Valid responses	Percentage split	
Gender	342	Male	43.3%
		Female	56.7%
Age	343	16-24	3.2%
		25-34	27.1%
		35-44	31.5%
		45-54	27.7%
		55+	10.5%
Site	366	Heriot-Watt University Research Park	36.6%
		Pentlands Science Park	19.9%
		Roslin BioCentre	6.6%
		Stirling University Research Park	25.1%
		West of Scotland Science Park	11.7%
Job type	366	Research	20.5%
		Technical/professional	40.2%
		Managerial	17.2%
		Admin/financial	18.6%
		Other	3.6%

6.3 Views from indoors

6.3.1 Access to window views

Ninety-three percent (n=341) of respondents reported doing the majority of their work at a particular desk or workstation. The vast majority of these (95%) reported having a window in the room they work in. Less than a third (29%) indicated that they face a window. It was much more common for desks or workstations to be located perpendicular to a window (53% of respondents). Working in a room without a window was more common for those in research roles; 11% of respondents in research lacked a window compared to 2-6% in the other job types. This is likely due to working in windowless laboratories.

The majority (73%) reported finding it easy (very or fairly easy) to see out of a window, whilst 19% found it very or fairly difficult. Unsurprisingly, those who only have a window behind them were more likely to report difficulty viewing out (see fig. 6.1a).

Overall, 96% of respondents were based either on the ground or first floors, reflecting the predominance of low rise buildings within this type of development. Those working on the ground floor were somewhat more likely to report difficulty viewing out than those working on higher floors (see fig. 6.1b). Security measures are likely to play a part in this – given that many of the organisations on science parks have expensive laboratory equipment on the premises and may also be undertaking work of a sensitive nature, there are good reasons to limit the view into the buildings from ground level.

Several open-ended survey responses reported dissatisfaction with ground floor windows elevated above eye level. Other ground floor respondents noted that their windows contained dark tinted glass, which impacted on the connection to the outdoor environment. One interview participant described these as being "good for security but bad for wellbeing", noting that this aspect of her working environment had caused her to consider leaving her job.

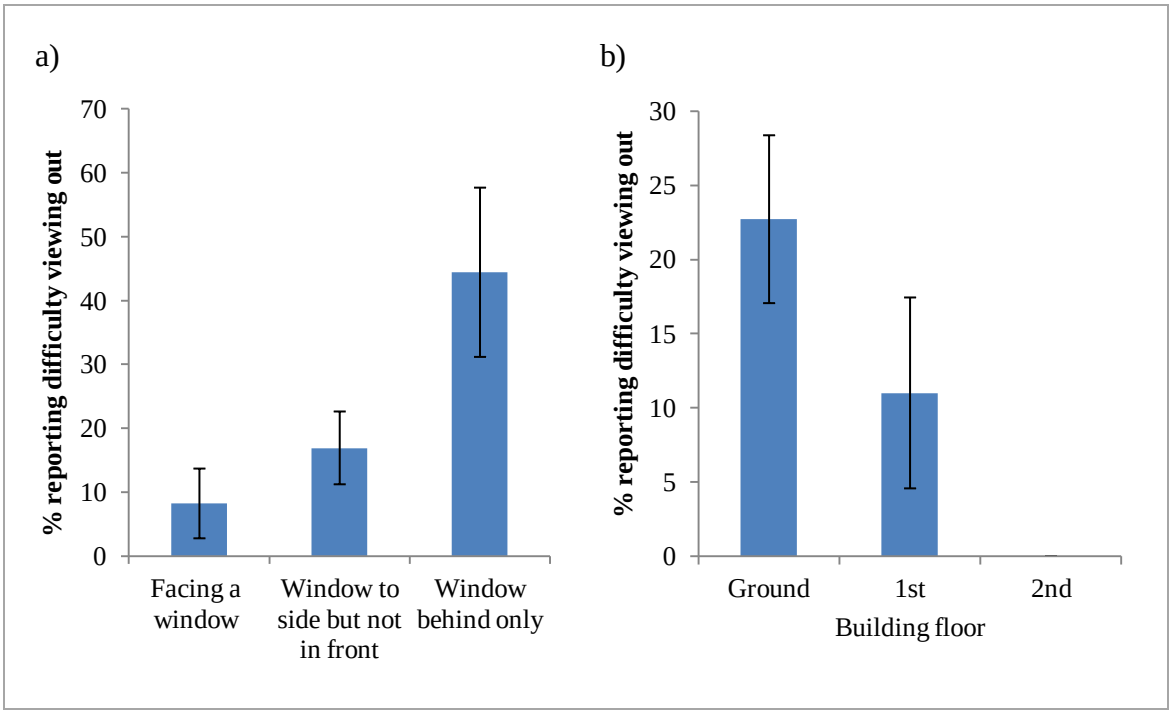

Figure 6.1: Difficulty viewing out by a) workstation orientation; b) building floor (NB: basement and 3rd floor omitted due to small number of cases). Bars show 95% CI.

Desk dividers were also mentioned by both survey respondents and interviewees as being a barrier to viewing out, either for the participants themselves or for colleagues. Blinds and other window coverings can also limit views out but these tend to have a more temporary effect. Very few (0.8%) reported having upwards of three-quarters of their view permanently blocked by these. Open ended survey responses and interview data indicated that window coverings are more of an impediment in sunny conditions when desires for daylight and views have to be balanced with issues of glare on computer screens.

6.3.2 Content of views

Survey respondents were asked to rate their view in terms of the balance between natural features (vegetation and water) and built features (buildings, roads and car parking etc.). Figure 6.2 shows that across the sites the majority (60%) of respondents' window views were predominately made up of natural landscape features (ratings of

'more natural than built' to 'completely natural'). Only 22% of respondents rated their primary window view as falling on the built side of the natural-built continuum, and just 6% reported an entirely built view. It is clear from this that despite extensive car parking, most of the workforce do not have their window view dominated by car parks or other built features.

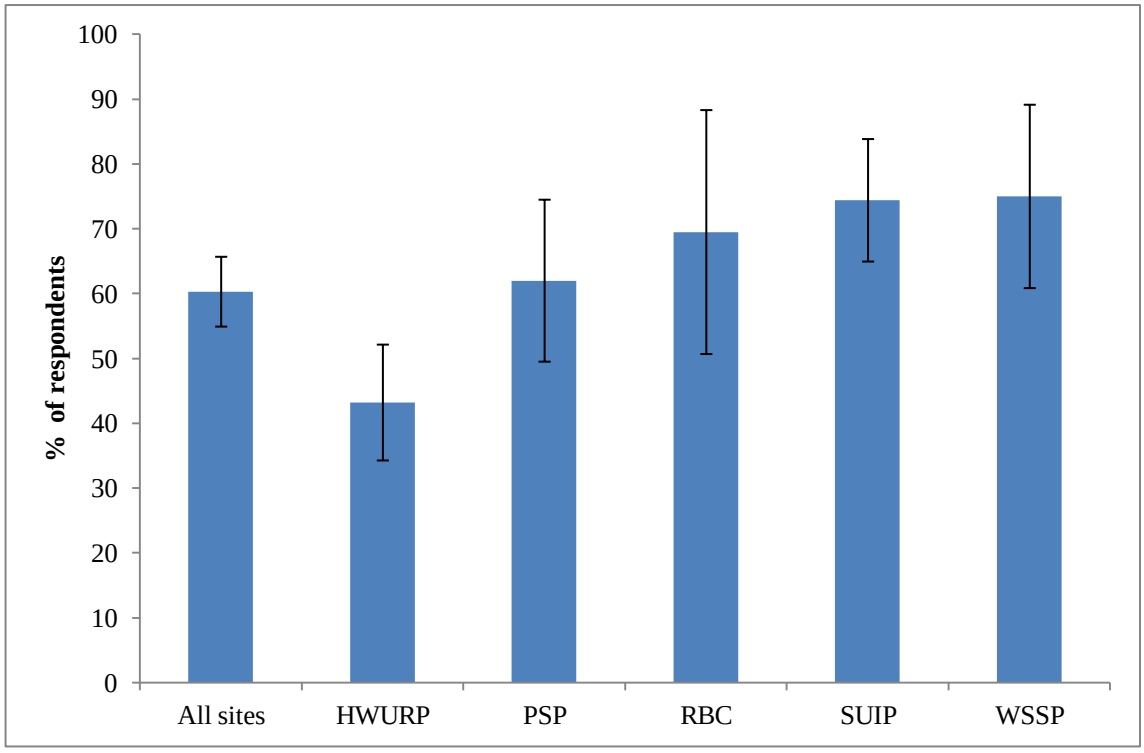

Figure 6.2: Percentage reporting a predominately natural primary window view by site. Bars show 95% confidence intervals.

Those at HWURP were least likely to report a predominately natural view; 43% did so, compared to 74-75% at SUIP and WSSP (fig. 6.2). Similarly, HWURP had the highest proportion (37%) of respondents rating their view as predominately built. The distribution of view naturalness ratings (made on a seven point scale) varied significantly between the study sites (Kruskal-Wallis chi-square statistic =27.455, df =4, $p<0.01$). Although WSSP had the highest proportion of respondents reporting a predominately natural view, the highest median naturalness ratings were at SUIP and RBC. There were no significant differences between the view naturalness ratings in the older and more recently developed areas of HWURP and WSSP, despite the differences in character and building density (HWURP east vs. west: Mann-Whitney U=1696.5, Z=-0.197, $p>0.05$; WSSP Kelvin vs. Todd: Mann-Whitney U=126.0, Z=-0.410, $p>0.05$).

It was hypothesised that having a more natural view would be associated with higher view satisfaction. A Spearman rank correlation test for non-parametric data confirmed

that there was a significant positive correlation between view satisfaction ratings and view naturalness (r_s= 0.330, p<0.01). This finding is consistent with those of Kaplan (1993), who found that employees' satisfaction with office window views increased with greater presence of natural features in the view.

Figure 6.3 shows the percentage of respondents reporting the presence of different features in their view. The most common view feature by far was trees/woodland, featuring to some extent in the view of 89% of the respondents to this item. Buildings, roads or car parking areas, and bushes/flowering plants also featured in the majority of respondents' views. The least common feature types reported were water features and sculptures, statues or other cultural artifacts, each present the view of in less than 5% of respondents.

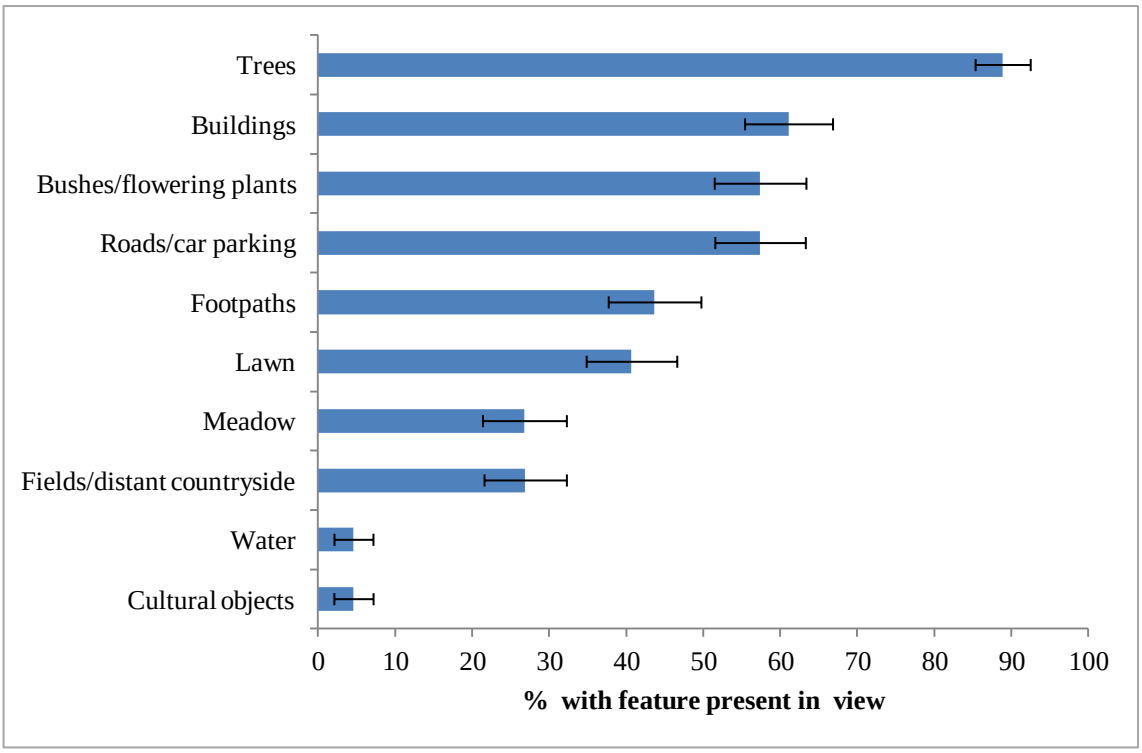

Figure 6.3: Presence of different feature types in window view. Bars show 95% CI.

6.4 Use of the open space on and around Science Park sites

6.4.1 Use levels

The survey gathered information about self-reported use of the outdoor space around the workplace in both the summer and winter months. Measures of both frequency of use (excluding passing through on the way in and out of work) and the duration of use over the course of a week (including passing through, to measure total exposure) were included in the questionnaire. The distribution of responses is described below.

Use frequency

Figure 6.4 shows that the majority of respondents spend time in the open space on a regular basis during the summer months; 20% reported daily use and a further 36% use it several times a week. Only 7% reported never using the outdoor space in summer. Overall, 71% of the respondents reported spending time outdoors around their workplace at least once a week in the summer months. As expected, frequent use was more common in summer than winter, and many more respondents reported using the open space only very occasionally, or never, in the winter than during the summer months. Despite this, the majority (55%) still reported using the open space at least once a week in winter.

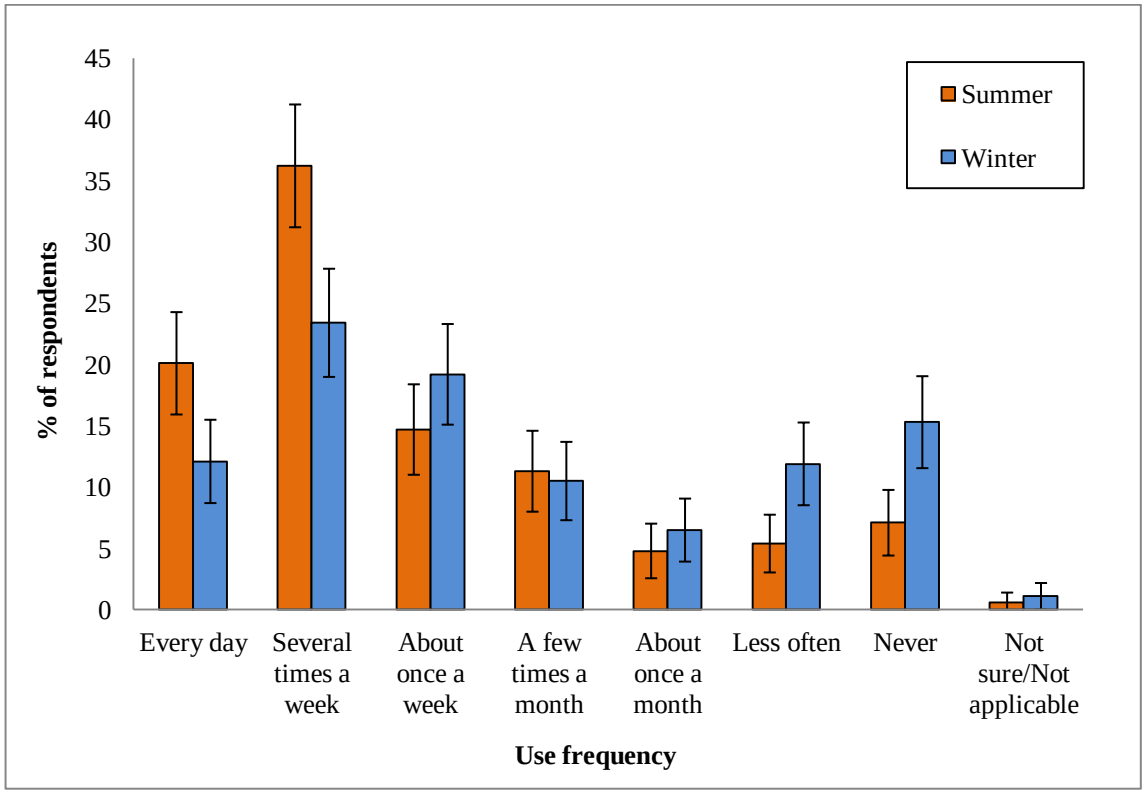

Figure 6.4: Use frequency in summer and winter (n=354). Bars show 95% CI.

These findings suggest substantially greater use of these workplace greenspaces than those investigated in the Danish study by Lottrup et al. (2012), in which just 38% reported using their workplace greenspace at least once a week. These findings can also be compared to Scottish data on use of local greenspace in the home context – in 2012 42% of adults used their local neighbourhood greenspace at least once a week (Scottish Government 2013b). Although this Scottish population sample is not directly comparable with the present sample, the relatively high frequency with which science park open spaces are used does point to the importance of such workplace contexts as a

setting for everyday interactions with greenspace. Engagement with greenspaces at business sites may, in fact, constitute a greater proportion of workers' overall exposure to greenspace across life domains than open spaces close to home.

Use duration

Over one third (38%) reported spending more than 1 hour a week in the open space during summer, falling to 25% in winter. A small proportion of the sample (10% in summer, falling to 6% in winter) reported spending longer than 3 hours in total per week in the outdoor space. At the same time, a significant proportion of the sample reported spending less than 15 minutes a week in the outdoor space; 14% in summer rising to 25% in winter (figure 6.5).

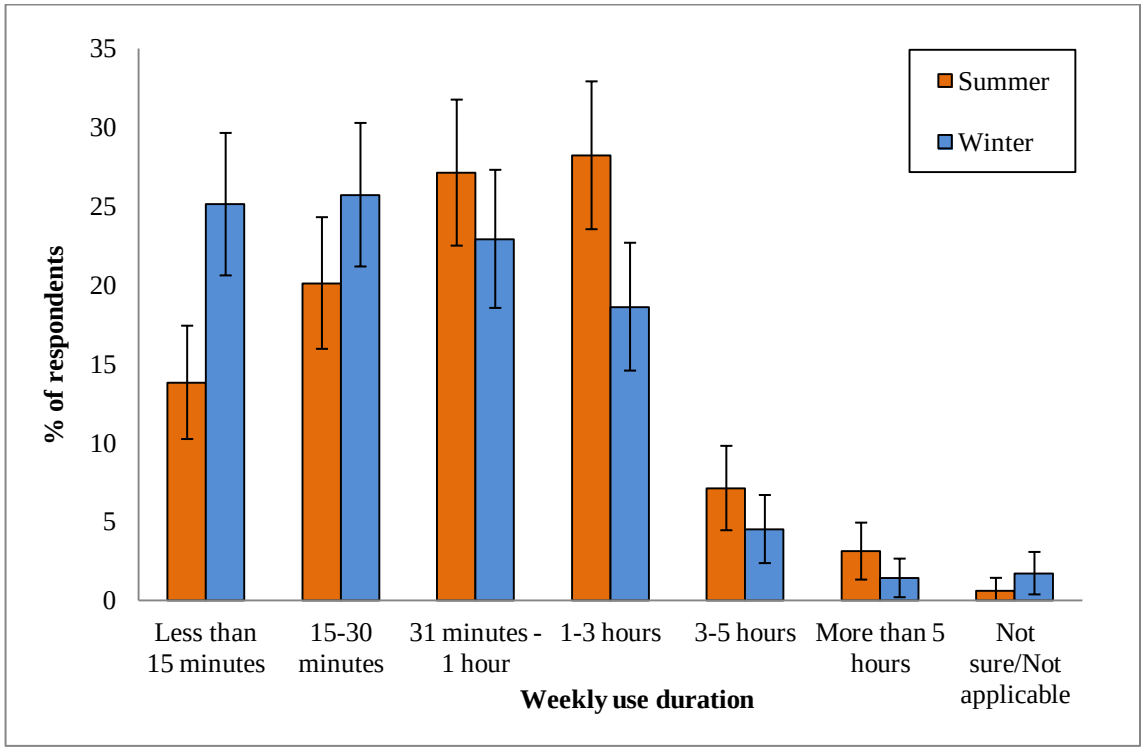

Figure 6.5: Weekly use duration in summer and winter (n=354). Bars show 95% CI.

Seasonal effects on use

Wilcoxon tests (a non-parametric equivalent to the paired t-test) confirmed that, as expected, individuals' use of the science park open space is significantly higher in summer than in winter, both in terms of use frequency ($Z=-10.947$, $p<0.01$) and weekly use duration ($Z=-10.1$, $p<0.01$).

There is a strong positive correlation between individuals' summer and winter use levels; those who use the open space more in summer tend to use it more in winter too, both in terms of use frequency ($r_s= 0.819$, $p<0.01$) and duration ($r_s= 0.814$, $p<0.01$).

Only a modest proportion (8.5%) of respondents who use the open space at least once a week in summer use it rarely or never in winter, so summer use does not appear to be dominated by warm weather use. Daily summer users often reported high use levels in winter too, with the majority (61%) continuing their daily use throughout the year.

6.4.2 Factors predicting use of science park open space

Binary logistic regression models were used to explore the extent to which reported use levels were related to working on particular sites, and to demographic and other factors. Four models predicted low use levels as measured in terms of use frequency and use duration. For these purposes, low use frequency was defined as less than weekly use. Low total use duration was defined as up to a total of 30 minutes per week in the open space. Use levels in summer and winter were modelled separately since exploratory analysis had indicated different patterns of predictors between the seasons. The models are summarised in table 6.3.

Both regular participation in outdoor activities during leisure time and using the open space for smoking appeared to influence both frequency and total duration of use, both in summer and winter. Those who reported taking part in outdoor activities at least once a week during leisure time were significantly less likely to report low use of the open space at work. Likewise, smokers were also less likely to report low use levels, although in terms of the weekly duration in the open space during winter this effect was only marginally significant ($p=0.073$). This relationship between smoking and open space use is to be expected since smoking in workplaces is banned in Scotland so those wishing to smoke must do so outdoors.

The models also indicated a gender effect on open space use, particularly during the winter months. In terms of both use frequency and duration, women were more than twice as likely as men to report low levels of winter use. The marginally significant gender effect for summer use frequency ($p=0.079$) suggests that women may also be slightly less likely to use the open space regularly during summer. This gender effect is consistent with previous research into use of greenspace at the workplace (Lottrup et al. 2012) and in other life domains (Ward Thompson et al. 2003, Cohen 2007, Tzoulas and James 2010). This disparity is often interpreted as being a result of perceptions of safety, however in this study very few respondents felt that safety considerations influenced their use of these spaces (see section 6.6.5). This gender difference was also

Table 6.3: Odds ratios in logistic regression models predicting low reported open space use levels **p≤0.01 *p≤0.05 †p≤0.1

	Summer use frequency <weekly (n=330)	Winter use frequency <weekly (n=328)	Summer use duration ≤30min/week (n=330)	Winter use duration ≤30 min/week (n=326)
Female	†1.736	**2.234	n/s	**2.502
Full time	*0.450	n/s	*0.401	n/s
Age 16-24	n/s	*7.938	n/s	n/s
Age 55+	*2.688	*2.886	n/s	n/s
PSP[a]	n/s	n/s	n/s	n/s
SUIP[a]	n/s	n/s	n/s	n/s
RBC[a]	n/s	n/s	n/s	n/s
WSSP[a]	n/s	n/s	†2.141	*2.377
Research work[b]	n/s	n/s	n/s	n/s
Admin work[b]	n/s	†2.072	n/s	n/s
Managerial work[b]	n/s	n/s	*2.223	n/s
Environmental sector	n/s	n/s	†0.549	**0.301
Mentally demanding work (very/extremely)	n/s	n/s	n/s	n/s
Stressful work (very/extremely)	n/s	n/s	**0.411	**0.422
Smoker	*0.180	**0.151	*0.177	†0.349
Outdoor activities frequency (≥weekly)	*0.217	**0.256	*0.423	**0.370
Omnibus test χ^2	**47.170	**59.477	**49.300	**64.480
Model fit (Cox & Snell R^2 - Nagelkerke R^2)	0.133-0.190	0.166-0.222	0.139-0.192	0.179-0.239

[a] Reference category = HWURP; [b] Reference category = Technical/professional

independent of working hours; although part-time working was more prevalent amongst female respondents, this cannot account for women's lower levels of use.

Working hours appeared to impact on employees' use of the open space during summer when use levels amongst the employee population are highest. Those working full-time rather than part-time were significantly less likely to report low summer use levels. This was seen both in terms of frequency and duration of use. It stands to reason that those spending more time at the workplace itself would report more frequent use as they have greater opportunity to use these particular spaces. It is likely that in winter when use levels are generally lower this effect is subsumed by other factors influencing attitudes towards going outdoors (e.g. weather and temperature).

The models also indicate an effect of age on the frequency of respondents' open space use. Exploratory cross-tabulations indicated that use levels tended to be highest amongst the intermediate age categories and lower in the youngest (16-24 years) and oldest (55+ years) respondents. When potential confounding factors were controlled through the statistical modelling this pattern remained to some extent. Those in the 55+ years age category were significantly more likely than those aged 25-54 to report using the workplace open space less than once a week, both in summer (by a factor of 2.7)

and winter (by a factor of 2.9). Although statistical power was limited in that only a small proportion (3%) of the sample were aged between 16 and 24, there was a marked divergence between this group's winter use frequency as compared to those in the reference group. Those aged 16-24 were almost 8 times more likely to report infrequent use of the open space during the winter months. There was, however, no significant difference for the 16-24 age group in terms of summer use frequency. Age therefore appears to influence use frequency, but not total use duration, with older employees using the open space significantly less frequently than those aged 25-54. Employees aged under 25 also report using the outdoor space less often, but only during winter. These findings contrast with previous workplace studies finding either no effect of age on use frequency (Lottrup et al. 2012) or *more* frequent use among younger employees (Hitchings 2010).

Strongly significant effects of job demands on the amount of time spent in the open space are apparent from the use duration models. Those who reported finding their work very or extremely stressful were significantly less likely to report spending less than 30 minutes in the open space each week, either during summer or winter. This suggests that experiencing high demands in terms of stress and consequently a greater need for stress relief, may act as a driver for use of the workplace open space. In contrast, no such effect of cognitive demands of respondents' work was found. It may be that the potential for stress reduction in and around science parks plays a more important part in influencing open space practices amongst employees than the potential for attention restoration. However, given that these associations cannot demonstrate directional effects, an alternative interpretation could be that spending greater time in the open space may result in finding work more stressful due to increased time pressure.

These regression analyses highlight the utility of measuring greenspace use not only in terms of frequency (as is often the case) but also the duration of time spent in the space. Whilst no effects of job stress on how often respondents use the outdoor space were found, there were clear associations with the amount of time spent there over the course of a week. The models also show an effect of site on use duration, supporting the results of exploratory Kruskal-Wallis tests which had indicated significant difference between sites in terms of use duration - in both summer ($\chi^2 = 9.555$, df = 4, $p<0.05$) and winter ($\chi^2 = 10.501$, df = 4, $p<0.05$) – but not use frequency (summer: $\chi^2 = 5.009$, df = 4, $p>0.05$; winter: $\chi^2 = 7.641$, df = 4, $p>0.05$). Those working at WSSP were significantly more likely to report spending only up to 30 minutes per week in the open

space on and around the site in winter, and marginally more likely to report little time spent there in summer.

Differences between those working in environmental sector organisations and others were also found with respect to use duration but not frequency. There was a strongly significant negative effect of environmental work on the likelihood of reporting spending less than 30 minutes per week in the outdoor space during winter, and in summer there was a marginally significant effect in the same direction. This indicates that, as expected, those who have greater professional interests relating to the environment are more likely to spend significant amounts of time in the open space available at their workplace. Previous research on the Scottish population has found environmentally engaged individuals to be more likely to both use greenspace frequently and attach high importance to it (Davidson et al. 2009).

Other factors associated with open space use at the science park sites related to professional roles. The results indicate that those who described their role as managerial were more likely than others to report spending less than 30 minutes per week using the open space during summer. This may be due to time constraints and workloads limiting how much time managers feel they can afford to spend on breaks, whether outdoors or indoors. We would expect the impact of time constraints to be most visible in summer when use duration amongst the employee population as a whole is higher.

6.5 Stated motivations for using the open space

Survey respondents were asked to select up to three main motivations for choosing to spend time outdoors around their workplace from a randomised list. Most of the motivation options supplied related to particular activities. Gehl (1987) discusses three types of activity in public space - necessary activities, optional activities, and social activities. Necessary activities are those that occur out of necessity rather than choice, and tend to take place regardless of weather, season, or other environmental conditions, whereas optional activities are more dependent on the environment. These (often recreational) activities tend to only take place when physical conditions invite them (Gehl 1987). Social activities are linked to either necessary or optional activities. The distinction between necessary and optional activities can be usefully applied to the analysis of the motivations for using the workplace open space given by survey respondents, as this item in the questionnaire was carefully worded so as to try to

exclude necessary activities, instead focusing on what motivates workers to go outdoors when they do so of their own volition.

Each respondent reported an average of 2.6 motivations. Figure 6.6 below shows the distribution of responses. Chi-square tests were performed to test for differences by study site, gender, age group and job type in the likelihood of reporting each motivation. In addition to the options provided in the checklist, participants could also state other motivations not listed. Many of those stated under 'other' related to necessary activities like getting to and from cars or public transport, or making trips to other buildings, shops, etc. Further optional activities described were varied and included dog-walking (particularly at PSP but also mentioned at HWURP), tending an allotment (PSP) or gardening on site, making private phone calls, and occasional work-related social activities such as a barbecue. The most unusual motivation for using the open space came from a respondent at PSP who reported practicing playing their trumpet in the woods because the trees absorb the noise well. Gehl (1987) suggests that poor quality outdoor areas support only necessary activities, whereas high quality outdoor areas invite a range of optional activities as well as encouraging people to take longer in going about necessary activities. Overall, the survey responses demonstrate that a wide range of activities, both necessary and optional, are undertaken in the green space on and around the science parks, which may reflect well on the quality of the environment at the sites.

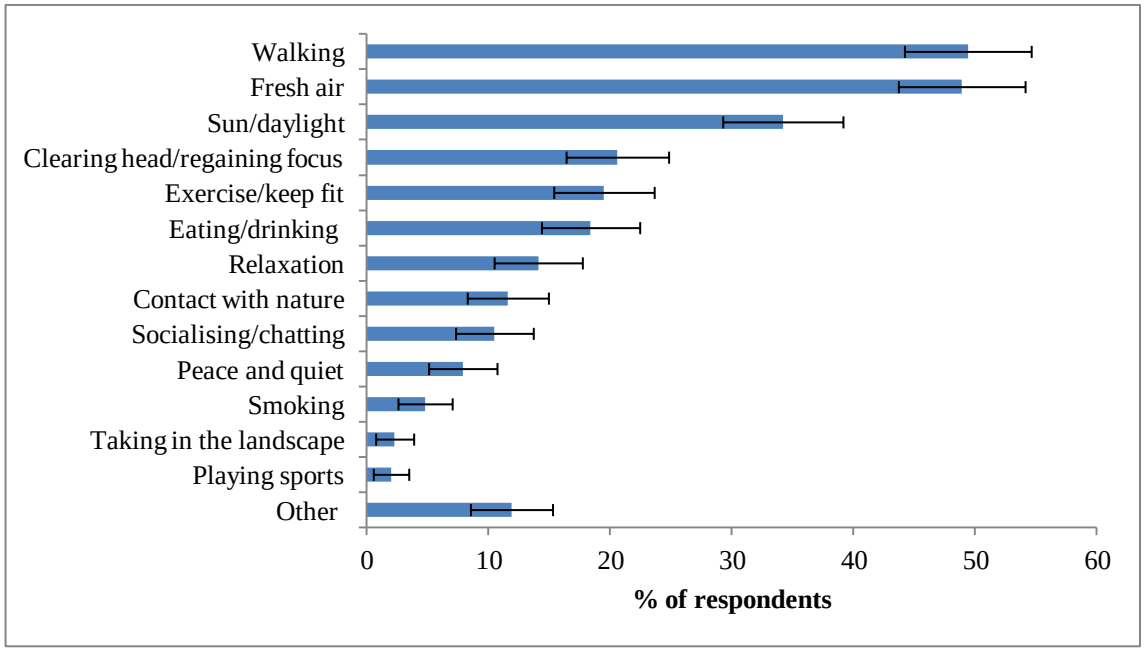

Figure 6.6: Motivations for choosing to spend time outdoors around the workplace. n=354.

Data from the qualitative study allowed users' motivations to be considered in greater depth than would have been possible using the survey data in isolation. The following sections therefore integrate the findings of both the quantitative and qualitative studies in regards to the main motivations reported by employees at the case study sites.

6.5.1 Physical activity

The most common motivation for spending time in the open space on or around the science park sites was to take a walk/stretch the legs, reported by 49.4% of respondents. Getting exercise/keeping fit was another fairly common motivation for use, reported by 19.5%. In addition, a small proportion of respondents (2%) reported playing sports or games as a motivation. Overall, almost two thirds (64.4%) of respondents selected at least one of these types of physical activity as a primary motivation for using the open space. A small number of open-ended responses detailing other motivations not listed also mentioned physical activities such as gardening/tending an allotment and dog walking.

The high proportion of survey respondents reporting motivations relating to physical activity suggests that for many of the employees, use of the open space tends to be mobile rather than stationary. Data from the walking interviews supported this; most participants (and particularly the more regular users) reported being on the move during most of their time outdoors around the workplace. Physical health was often discussed as a primary consideration driving physical activity in the greenspace, with psychological benefits seen by many as an important by-product but not necessarily the driving force behind their use of the open space, reflecting previous findings on motivations for use of public parks (Irvine et al. 2013, cf. Ward Thompson and Aspinall 2011). For some, being physically active in the open space at work was a key part of a regular exercise regime, whereas for others there was less of an emphasis on 'keeping fit' and more on breaking from the sedentary nature of their work, associated with both physical and mental benefits:

> *"My job is sitting down, either at a computer or a microscope and you know, that's not great for your health but taking the time to come and have a walk - you know, you feel better because you are moving, you're walking, your blood is circulating, it's getting fresh air into you and its allowing you to think a bit clearer. I don't... I wouldn't say I go out for the exercise but it certainly contributes to making me feel better".* (Interview participant, HWURP).

The prominent role of physical activity in employees' use of greenspace at science park workplaces contrasts with the study by Lottrup et al. (2012) in which only 16% of employees reported undertaking physical activity in their workplace greenspace. Differences in the type of open space studied may help to explain this difference - the study by Lottrup et al. focused on spaces like gardens, on-site woodland, courtyards and roof terraces associated with large single-user business developments. In comparison, the present study looks also at the use of nearby open space in the wider area as well as within the science parks. The greater opportunities for green exercise offered by large heterogeneous sites with links to wider peri-urban green environments may promote more active use. Workplace open spaces such as courtyards and roof terraces may also offer more seating as part of their design, therefore being more compatible with sedentary uses.

The proportion of respondents reporting taking a walk as a primary motivation varied significantly between the study sites (χ^2=10.288, df=4, $p<0.05$). Only 31.0% of respondents at WSSP reported walking as a motivation, compared to 42.3% at PSP and 50.0-56.2% at the other sites. It is not clear why this might be. Comparison of the two areas of WSSP (Kelvin vs. Todd Campus) found no difference in the proportion reporting this motivation at each campus (33.3% and 30.0% respectively), indicating that a factor common to both areas may be responsible. Lesser inclinations towards physical activity at WSSP may help to explain the lower use levels observed there and reported in section 6.4.2. It is possible that the more urban setting of WSSP, relative to the other sites, might play a part in these relationships.

6.5.2 Fresh air, sun and daylight

Getting fresh air was the second most commonly stated motivation for spending time outdoors in the open space, reported by almost half (48.9%) of respondents. This appears to be related to a desire for a contrast or escape from the experience of the indoor workplace environment. Several interview participants described their office buildings as stuffy and overly warm (both in summer and winter), so the opportunity to both breathe fresh air and cool down was a key motivator for taking a break outdoors. One participant highlighted the salience of this motivation with respect to heat generating processes that would be absent in traditional offices:

> *"There's so much machinery in the building that even with ventilation and opening the windows.. I mean in summer, we have some labs that have 10 or 12 fridge freezers and bits of electrical equipment everywhere, it's all pumping out heat and you just kind of overheat and you know, start to feel a bit woozy."* (Interview participant, PSP).

Over one third (34.2%) reported sun/daylight as a main motivating factor. Again this motivation was mentioned by many of the interview participants, a few of whom reported only spending time in the open space on bright and sunny days. Participants commonly discussed desires to 'make the most of the sun' on good days. This seemed to be widespread within their organisations, as it was not unusual for colleagues to head outdoors *en masse* at lunchtime on particularly fine summer days.

One participant, in contrast to those for whom sunlight was a major driver of summer use, described daylight as being a key factor influencing winter practices:

> *"Possibly even more in the winter because it's so dark when I'm coming to and from work, it's just nice to see things in the daylight. So I'm much more likely to come for a walk in the winter."* (Interview participant, PSP).

Motivations to go outside for sunlight or daylight may therefore be pertinent both in summer when there are more warm and sunny days to take advantage of, and in winter when opportunities to be outdoors in daylight outside of work are constrained.

Women were significantly more likely than men to report motivations for fresh air (χ^2=6.054, df=1, p<0.05) and sun/daylight (χ^2=8.444, df=1, p<0.01). Almost 55% of female respondents reported fresh air as a motivation, compared to just over 41% of men. Similarly, whilst around 41% of women reported motivations for sunshine/daylight, only around 26% of men did so. The qualitative study indicated that thermal comfort (as well as air quality) plays a part in motivations to get outdoors for fresh air. There is some evidence indicating that women may be more sensitive to the thermal environment than men (Karjalainen 2007, Karjalainen 2012), which could explain the gender difference in the reporting of this motivation for open space use. Women are also more likely than men to report symptoms of Sick Building Syndrome, linked to thermal discomfort and indoor air quality (Brasche et al. 2001, Bakke et al. 2007, Karjalainen 2012). Gender effects in responses to lighting conditions have also been demonstrated in previous studies - women have been found to experience more positive mood states and to perform better than men at mental tasks in wavelengths of light associated with daylight, as opposed to 'warmer' lighting conditions (Knez 2001,

Knez and Enmarker 2013). Lack of natural daylight, tending to occur during the winter months in northern latitudes, is also associated with Seasonal Affective Disorder, which women (particularly those of child-bearing age) are more likely to suffer from (Rosenthal 1998, Kane and Lowis 1999, Mersch et al. 1999). One possible interpretation could therefore be that female respondents were more sensitive to the indoor physical environment of the workplace, resulting in greater motivations to get outdoors for fresh air and sun/daylight as an adaptive behavioural response to adverse indoor conditions. Although some of the gender differences in the literature reported above may be a function of a reporting bias (since women tend to be less reluctant to report health problems), this line of reasoning would benefit from further inquiry.

There was also a significant difference between age groups with regards to reporting sun/daylight as a motivation for use (χ^2=8.7.256, df=2, p<0.05). Those in the 16-24 age group were much more likely to report this as a primary motivation (54.5%), particularly compared to those aged over 55 (only 16.7% of this reported this motivation). This difference may help to explain why, in the models reported in table 6.3, those aged 16-24 were more likely than the reference category of 25-54 year olds to report low use frequency during winter but no such difference emerged for the summer months.

6.5.3 Restoration, nature and landscape

Around a fifth of respondents (20.6%) reported clearing the head/regaining focus as a motivation. This motivation can be seen as analogous to attention restoration, whilst the option 'to relax/forget about work hassles' (selected by 14.1%) was included to represent the relaxation and stress relief dimension of restoration. Overall one third of respondents reported at least one of these motivations for restoration. These results show that although these motivations for psychological restoration do not feature as heavily as others such as taking a walk, getting fresh air and natural daylight/sun (all of which are often constrained within the workplace by the sedentary, office-based nature of most knowledge-sector employment), they remain important motivations for many. The higher proportion of respondents reporting attention restoration as a motivation may indicate that this is a more common reason for science park open space use within this group than is stress management, at least in terms of respondents' conscious motivations. There is, however, no clear difference in the reporting of attention restoration and stress relief motivations due to the overlap in confidence intervals. In

addition, 7.9% of respondents reported getting peace and quiet as a motivation. This motivation could relate to both attention restoration (being away) and stress relief (escaping from stressors).

There was a significant difference in the proportions of respondents reporting attention restoration motivations ('clearing head/regaining focus') between job types (χ^2=8.403, df=3, p<0.05). This difference may be related to the demands associated with different roles, since the pattern amongst the job types reflects the proportions of respondents in each job category reporting their work as being very/extremely mentally demanding (see fig. 6.7).

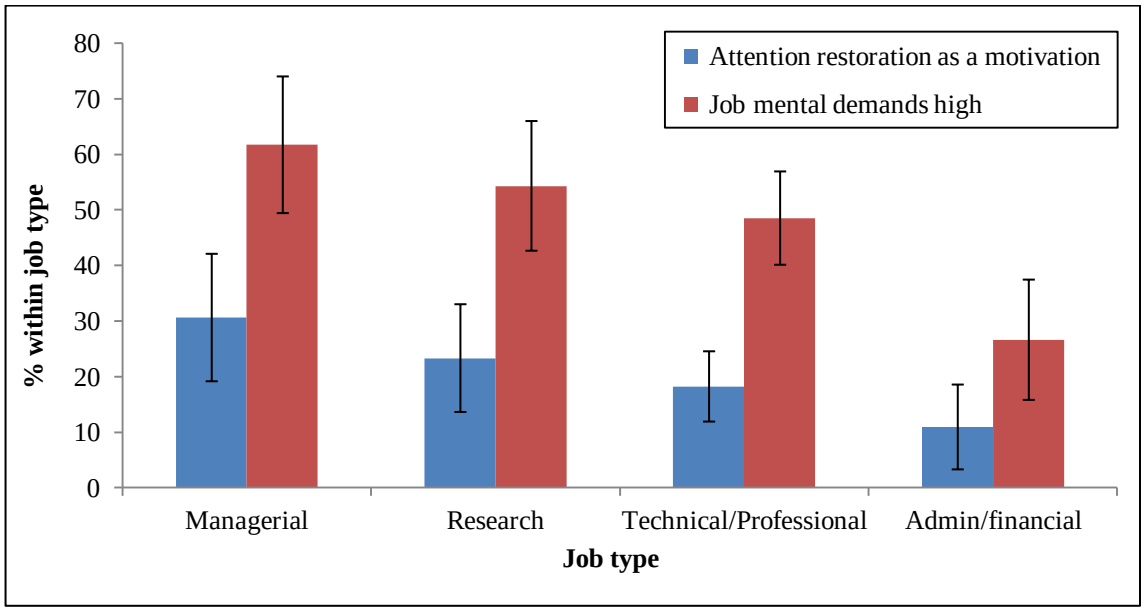

Figure 6.7: Proportions of employees selecting the attention restoration motivation and reporting high mental demands at work (rated as very/extremely demanding) by job type.

Seeking contact with nature appears to feature less strongly in employees' motivations than conscious desires for psychological restoration, with 11.6% reporting this as a primary reason for using the open space. In contrast, only a small proportion reported being motivated by the opportunity to take in the landscape (2.3%). The proportion reporting motivations for contact with nature again varied by job type (χ^2=12.993, df=3, p<0.01). None of the respondents in admin/financial work reported this as a primary motivation, and only 8.1% of managers did so. Research and technical/professional staff were more likely to report this motivation (15.1% and 16.1% respectively, compared to 8.1% of managers and 0% of admin/financial staff). This may be explained by the fact that a relatively high proportion of respondents in these roles were environmental sector employees - 48% of researchers and 35% of technical/professional staff (compared to 16% of admin/finance and 17.5% of managers) worked in

environmental organisations. In the sample as a whole, those in environmental work were more likely to report contact with nature as a motivation for their open space use (18.9%, compared to 8.5% in other business sectors).

6.5.4 Eating and drinking

Although data from the qualitative study suggested that open space use tended to occur during lunch breaks rather than at other times of the day, eating and drinking outdoors was stated by only 18.4% as a primary reason for using the space. This contrasts to the findings of the Danish study by Lottrup et al. (2012) where this was the most common activity undertaken in workplace open spaces, reported by 45% of respondents. As noted in section 6.5.1, differences in the characteristics of the knowledge-sector greenspaces studied may help to explain this contrast, with science parks offering greater compatibility with active than sedentary uses of the open space. The qualitative interview data also suggest that both the presence and the qualities of seating areas influence the extent to which more passive, sedentary activities like eating and drinking are performed. This is discussed further in section 6.6.4.

6.5.5 Social activities

Eating and drinking in the open space was reported as a primarily social experience by several interview participants. Active uses of the space, such as walking or running, were also often social activities for a number of participants. Overall, socialising or chatting to others was reported as a primary motivation for using the open space by only 10.5% of survey respondents. However, when looking at reported *practices* within the open space, almost a third (31.2%) of respondents reported spending most of their time there in company, with a further 19.1% spending roughly the same amount of time with others as alone. Men were significantly more likely than women to report socialising or chatting as a motivation for spending time outdoors around the workplace (16.2% of men compared to 6.7% of women, χ^2=7.878, df=1, p<0.01). There was, however, no difference between the proportions of men and women reporting spending most of their time in the open space with others (χ^2=0.109, df=1, p>0.05). Similarly there was a significant difference between age groups in reporting socialising as a motivation (χ^2=8.531, df=2, p<0.05); only 5.6% of the 55+ group reported this as a reason for using the open space, compared to 36.4% of the 16-24 group and 10.5% of the intermediate group. However, there was again no difference in the proportions of each age group

reporting that the majority of their outdoor time was spent with others (χ^2=1.783, df=2, p>0.05).

The qualitative data from the walking interviews highlighted a strong influence of social norms and workplace cultures in shaping social use of the open space. In some interview participants' workplaces, shared drives for health and fitness promoted group walking or running. In some cases this culture of getting outdoors together for physical activity was well established, with a number of colleagues taking part in group runs or walks on at least a weekly basis. Other participants described these occurrences as less habitual e.g. when one or more individual in a team or social group was on a 'health kick'; it seems that such periods of taking walks together often fail to become a sustained routine. In other cases physical activity as part of a group was more functional; cultures of going to lunch together (e.g. in a cafeteria located in a different building on the park, or university catering facilities) promoted group walks which, in good weather, often included detours to extend the walk back to the office.

More passive social use was reported in some organisations where eating lunch or spending coffee breaks outdoors together was the norm in good weather. To a large extent this type of outdoor culture depended on the compatibility of the space; these organisations tended to have direct access to seating areas in the immediate vicinity of the building (see section 6.6.4 for further discussion of the role of seating infrastructure). Interview participants in these organisations also tended to describe breaks as being a social experience, whether indoors or outdoors. Therefore it seems likely that workplace cultures favouring regular (passive) social use of the outdoor space depend on pre-existing norms for breaks to be shared social activities which can, given compatible outdoor environments, be reproduced outdoors.

Overall, the disparity between the low proportion stating motivations for socialising on the one hand, and the relatively high prevalence of social use of the outdoor space on the other - alongside the evidence on the role of workplace cultures - suggests that patterns of social use may be explained more by norms within particular companies than individuals' explicit motivations for social experiences outside of the normal indoor working environment.

Interview participants tended to describe social interactions in the open space with reference to colleagues in the same organisation, reporting outdoor interactions between employees of different companies on site as being minimal. One exception was at

RBC, where one participant described regular use of the picnic benches at the Wallace Building by individuals from a number of small tenant companies. This was seen as a positive opportunity to mix and interact with neighbours.

This evidence allows some conclusions to be drawn with regards the potential role of science park open space in building social capital and social networks. Putnam (2000) describes two dimensions of social capital - bonding and bridging. Bonding (or exclusive) social capital refers to inward-looking ties within homogeneous groups, whereas bridging (or inclusive) capital is more outward-looking, bringing together people from heterogeneous groups. The evidence suggests that employees' social use of open space on the study sites contributes primarily towards bonding social capital, with bridging social capital between organisations being marginal. Social experiences which promote bonding within organisations may be very valuable in supporting employee wellbeing by increasing reciprocity and solidarity between colleagues. However, it has been suggested that bridging social capital is more useful for creating positive externalities resulting in wider value for society as a whole (Putnam 2000). In the science park context this might mean informal opportunities for cross-pollination of ideas, promoting innovation and potential collaborations. The idea that co-location on a site should promote collaboration and innovation is embedded within the rationale underlying both models of science park development and cluster development in general (Westhead and Batstone 1998, European Commission 2008, Link 2009). The example of social mixing across companies at RBC may indicate that there is some potential for open space to contribute towards enhancing bridging capital in science parks. However, it is questionable as to whether this would promote knowledge-exchange or cross-pollination of ideas - one participant at RBC noted that "we don't so much discuss what the companies do but there is interaction.... usually you go down there and it's just talking about any old stuff". This participant went on to discuss his previous attempts to instigate a regular scientific discussion club had failed:

> *"Some of the people didn't like it, especially the bosses, didn't like it because they thought there was a danger of some of the younger employees starting to say what the company actually does - let slip some sort of patented thing."*

This illustrates that although it may be possible for open space to promote bridging social capital between companies on science parks, the reality of outdoor social interactions during breaks means that they unlikely to contribute to innovation and

knowledge exchange a meaningful way. Furthermore, there are significant structural barriers relating to intellectual property which work against such cross-pollination of ideas, whether interactions occur indoors or outdoors.

6.6 Barriers to use

Survey respondents were presented with a checklist of potential barriers to their use of the open space and asked to select any that applied. Ninety percent selected at least one constraint from the list, with respondents reporting 1.4 barriers on average. This contrasts with the findings of the survey by Lottrup et al. (2012); between half and three-quarters of the respondents in that study (depending on the site) reported no barriers to use of their workplace greenspace.

The distribution of responses is shown in figure 6.8. The barriers commonly reported by survey respondents were less varied than the reported motivations for spending time in the open space. Only three constraints were reported by upwards of 10% of the sample; weather/climate conditions was most commonly reported, followed by lack of time, and to a lesser extent not having enough places to sit. These reported barriers are explored further in the following sections with reference to the findings of the qualitative study. Chi-square tests were again performed to test for differences by study site, gender, age group and job type in the likelihood of reporting each of the constraints. There were much fewer between-group differences in the barriers to use reported; the only difference found was a gender difference in reporting of 'lack of places to sit' as a barrier (see 6.6.4).

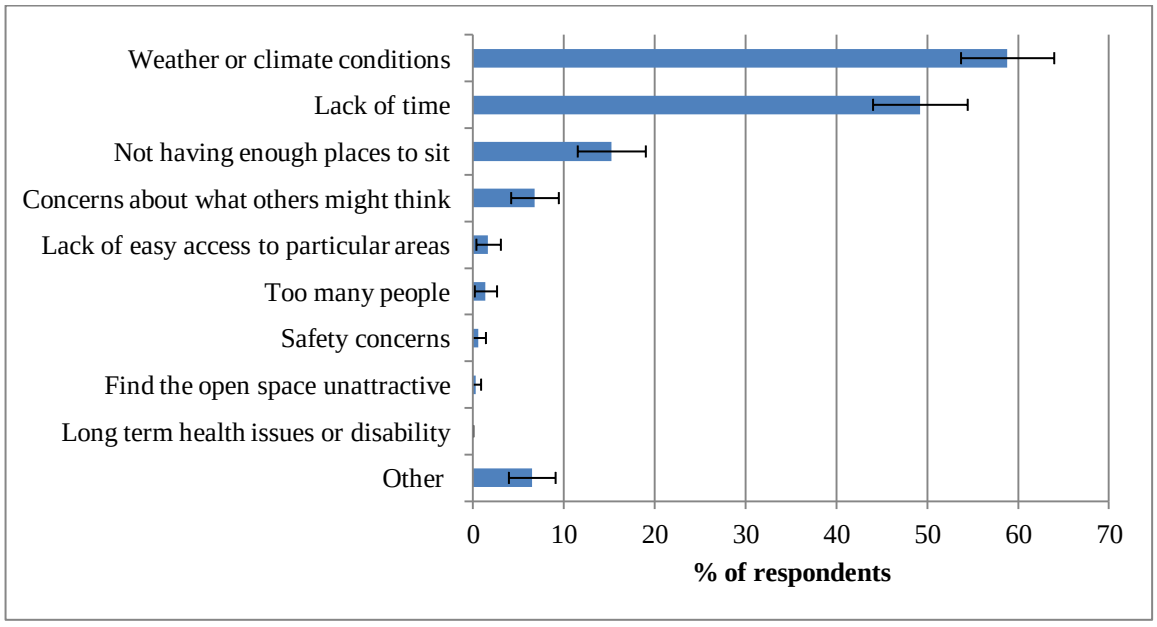

Figure 6.8: Barriers to use of outdoor space around the workplace. n=354.

6.6.1 Weather and climate

'Weather or climate conditions' was the most commonly reported barrier (58.8% of respondents). This was not surprising, especially given that the survey took place in the (rather wet) summer after a severe winter. The qualitative study confirmed the importance of weather in shaping open space use. Whilst most interview participants were discouraged from going outdoors at all in heavy rain and snow, and keen to get outdoors in warm, sunny weather, the extent to which intermediate weather conditions acted as a barrier to use depended on the activity in question. Participants commonly reported only engaging in sedentary activities like sitting eating lunch or drinking coffee on warm summer days. Even when bright and warm, the exposed nature of some of the seating areas available meant that users were sometimes put off sitting out by the wind. More active uses were less dependent on good weather. The regular walkers were generally unfazed by moderately cold weather, given that it is easy to wrap up against the cold and walking raises body temperature, however strong winds proved to be a deterrent for many. Some were happy to go out in light rain as long as they had a hood or umbrella, whereas others tended to only walk in dry weather. Running appeared to be least dependent on weather; the regular runners in the interview sample reported being motivated to keep up their routine throughout the year and in varying weather conditions:

> *"Nothing really puts us off. In fact the only time that we were really careful was when I think the snow started to melt and then it froze again so it just went like sheet ice and we were... but we still went out."* (Interview participant, RBC).

It seems that the more vigorous the activity, the less participants were discouraged by inclement weather. This appears to be a product of two factors: firstly, physical activity makes it easier to stay warm in cold conditions, and secondly, those who use the open space as part of their regular keep fit regime were highly committed to sustaining their routine regardless of the weather. For others, particular weather conditions were seen to invite congruent activities:

> *"When it was hot in April I was out every day, just sat out in the sun, which was lovely. I tend to go for a walk when it's a bit colder, I don't tend to walk when it's sunny cos I tend to just want to sit and read my book. When it's a bit colder I like to go out and just have a wander.*" (Interview participant, WSSP).

6.6.2 Time pressure and productivity

The other barrier to use commonly reported by the survey respondents was 'lack of time' (49.2%). Time pressure and workloads have previously been reported as major constraints to use of greenspace in the workplace context (Hitchings 2010, Lottrup et al. 2012).

Several interview participants described how their workload influences decisions to spend time outdoors during breaks. This factor was seen to limit both the frequency and duration of open space use, with participants commonly reporting taking only a short (indoor) lunch break to eat, or eating at their desk, when 'pushed for time'. One participant related current work pressures to organisational changes as a result of the recession:

> *"...there's lots of contraction of numbers of people so there isn't so much time for walking, getting out at lunchtime. We're supposed to take half an hour for lunch but I certainly don't, most days."* (Interview participant, PSP)

Time constraints also influenced indoor vs. outdoor practices in cases where set lunch breaks were adhered to. Whilst some felt that having a set lunch break meant that there was always the opportunity to spend time outdoors if desired others felt that the duration of their lunch break limited their opportunity to spend time outdoors. This belief was held not only by participants who had a short 30 minute lunch break, but also by one who had a full hour for lunch. This participant at SUIP reported the perception that although she might have time to get outdoors during her lunch break, the time constraint would limit the benefits of doing so:

> *"My youngest colleague she'll go out for a walk, even if it's only 15 minutes she'll say 'well I'm just going to go out and get some fresh air' whereas I don't do that because for me 15 minutes isn't enough to assuage all my..... you know it's not, I'm not, I don't mean to say that I'm feeling stressed at work or anything like that, but if I'm going to go for a walk I like a long length of time to walk so I wouldn't ever think 'oh I've got 15 minutes I'll go out for a walk'."* (Interview participant, SUIP)

Although meta-analysis has indicated that just five minutes in greenspace can produce a measurable psychological benefit (Barton and Pretty 2010), in several cases there was an underlying perception that if the duration of the lunch break did not allow for a meaningful amount of time outside (or 'proper walk') there was little point in spending some of it outdoors. Other authors have considered what constitutes a 'meaningful

portion of time' in greenspace, defining this with respect to effects on self-reported vitality as at least 20 minutes (Ryan et al. 2010). This broadly corresponds to the reported duration of walks reported by interviewees – most participants reported that when taking a walk or run for its own sake this lasted around 20-30 minutes, with some spending longer (up to around 45 minutes). Some individuals reported taking shorter walks of around 10 minutes on occasion; however the duration of these visits short visits outdoors were reported to be shaped more by time pressures than personal preferences.

This strong influence of time and workload considerations on the duration of outdoor breaks had implications for the routes participants reported taking. In a few cases, participants reported avoiding particular routes or paths because they were unsure about how long they would take to walk and did not want to overrun their set lunch break. For others, knowing the time required to walk a range of routes or variations meant that some regular users were able choose from a mental menu of routes according to the time budgeted. This suggests that providing access to a range of short-distance (10-45 minute) walking routes (perhaps supported by information on route options and walking times) might help to promote walking amongst less frequent users.

In Hitchings' (2009, 2010) qualitative study of city-centre office workers one factor that was seen to strongly influence orientations towards spending time outdoors was participants' drive for purposefulness. Similarly, in the present study there was a sense from some that desires to keep focused and productive meant that the idea of devoting some time to relaxation during the working day was not on the agenda:

> *"I mean there's the... there's the temptation that once you get behind your desk and you get moving with work, just to kind of stick at it cos you're on a bit of a roll basically... and kind of you only realise how much you've got to do when you actually sit down at your desk so there's the temptation not to move away from it."* (Interview participant, HWURP)

The idea of being "here to work", linked both to purposefulness and conscientiousness, was most clearly seen in participants' attitudes towards taking (even very brief) outdoor 'booster breaks' (Taylor 2005, Hartig 2006) at times other than during lunch. Most felt that to do this would be a dereliction of duty, the exceptions being participants who were either self-employed, worked flexitime, or worked in an organisation where communal mid-morning breaks (sometimes outdoors) were the norm. These norms are discussed further in the following section.

6.6.3 Other people's perceptions and workplace norms

The previous example hints and the role of behavioural norms and workplace cultures as a barrier to use of the open space. The focus theory of normative conduct (Cialdini et al. 1991) distinguishes between descriptive and injunctive norms. Descriptive ('is') norms relate to perceptions of what the majority do, whereas injunctive ('ought') norms refer to whether particular behaviours meet with widespread approval or disapproval within a cultural context (Cialdini et al. 1991, Schultz et al. 2007).

In the survey, 6.8% of respondents reported their use of the space to be limited to some extent by concerns about the fact that others might think that spending time outdoors is not an appropriate use of their time. This points to the existence of certain injunctive norms within some organisations on the study sites acting as a barrier to use, since the perception of these respondents appears to be that spending time outdoors goes against prescribed modes of conduct. Descriptive norms may also play a significant part in informing behaviour in this context, as indicated by open-ended survey responses and the interview data. One survey respondent hinted at the influence of descriptive workplace norms on her own behaviour: "at my old work I used to run most days at lunch time - there is a different attitude here".

Social norms in the workplace regarding both *if* and *when* the open space is used emerged as a significant factor in the qualitative interviews. Some respondents described their workplace as having an ingrained culture of spending the entire day indoors. The root of these norms was often put down to the tendency to live the day in a kind of 'office bubble' - going into work, "getting your hours in" at your desk and then going home - and/or a culture of inactivity linked to both sedentary work and car dependency for commuting. In contrast, the interview participants working in environmental sector organisations described workplace cultures more conducive to outdoor engagement - although breaks outdoors were not necessarily the norm in descriptive terms, they were at least seen to be a common and accepted practice in these organisations. There were also examples of how the promotion of healthy outdoor lifestyles formed part of the ethos of these organisations at a management level, increasing the salience of injunctive norms favouring physical activity and outdoor engagement. Participants from one organisation highlighted some of the ways in which this ethos was encouraged by management via a funded staff committee - from the provision of allotments for employees, to organising events such as a 'Mushroom Day'

involving guided walks and education, competitions like step-count challenges and informal running clubs and weekly outdoor circuit training.

As described in section 6.6.2, there were strong norms operating around *when* it was acceptable to take an outdoor break. When it came to the idea of unnecessarily going outdoors outside of defined break times, these injunctive norms prescribing purposefulness and conscientiousness were seen to override any competing norms encouraging outdoor use. The common attitude was that going outdoors at these other times would jar both with the culture of the workplace and with the individual's own identity as a diligent employee. One would need a legitimate reason – an 'outdoor alibi' (Hitchings 2010) to go out during prescribed working time. Interestingly, in some organisations smoking was seen to be an accepted reason to 'down tools', whereas going out for a breath of fresh air was not. Flexible working hours can, however, counter this prevailing norm - being able to clock out for any reason and then make the time up elsewhere meant for one participant that in his organisation there were no injunctive norms prescribing the acceptability of brief outdoor breaks for whatever reason.

Finally, lower-order norms around the theme of being sociable emerged as a barrier both to use of the open space (where indoor social breaks were the norm) and to walking (where outdoor breaks were more common but normally social and sedentary). A solo walker at HWURP also noted:

> *"Perhaps on the occasion that everybody else is out of the office for one reason or another and it's just me then I'll probably go out for a wander more often than otherwise because you feel like you're being a bit antisocial sometimes – heading out for a walk when other people are wanting to have their lunch and have a chat or what have you."*

One participant at PSP discussed the influence of communal (indoor) coffee breaks with her colleagues on the behaviour of the group as a whole:

> *"You know, my group, precisely at 10 o'clock and 3 o'clock, and you are institutionalised into it... I guess cos that's the social time, where everybody wants to kinda do that. But yeah I think people move in herds and if more people broke the mould and came outside you'd probably find that the rest of their herd would, you know?"*

It may be that in workplaces where strong social groups exist and breaks are predominately a communal activity, attempts to promote open space use could benefit from focusing on opportunities for social use of the space.

6.6.4 Park infrastructure

Seating provision

Not having enough places to sit was selected by 15.0% of respondents as a barrier to their use of the open space. Female respondents were significantly more likely to report this constraint (χ^2=6.532, df=1, p<0.05) - 18.6% of women compared to 8.8% of men in the sample selected this as a barrier to use.

Although the study sites varied substantially in terms of the seating provision, there were no significant differences between the proportion of respondents at each site reporting a lack of places to sit as a barrier to use (χ^2=2.555, df=4, p>0.05). Across the sites, the aspect of the environment that most respondents said they would change was the level of seating provision; 72% would like to see more seating at their site. There was an apparent contradiction between this widespread demand for greater seating provision and indications from the walking interviews that some seating areas were underutilised. This suggests barriers to sitting out stem not only from limitations in the quantity of seating provided, but also the quality and characteristics of seating areas. Given a compatible location, picnic tables appeared to support more use than benches, possibly because sedentary activities performed in the open space usually included eating lunch or taking coffee breaks outdoors, and were often undertaken as part of a group.

Location of seating

A number of open-ended questionnaire responses cited dissatisfaction with the quality of seating areas as a barrier to use e.g. when located next to car parking areas. Several interview participants reported being discouraged from using some seating are due to their setting in exposed and windy locations.

The qualitative study also highlighted examples of seating areas which, although considered attractive by participants, were very seldom used (both by the participants and others on the site). These tended to be located in communal areas where there was no sense of ownership of the space by any particular organisation. A few participants were unsure about whether it was appropriate for them to use particular seating areas in the shared open space areas, or whether these were for the use of specific companies. In contrast, the relatively heavily used seating tended to be located in the immediate area

of the buildings (usually adjacent to doors), where the space was perceived to fall more within their organisation's territory.

This highlights two related factors determining the use of seating infrastructure: a) proximity to the office and b) perceived ownership of the space. In many cases the seating infrastructure, often consisting of picnic benches, was provided by the organisation rather than as part of the science park infrastructure, which further cements the sense of ownership of the space. Well-used seating areas were also often located towards the back or side of buildings where participants felt less of a sense of being situated in an overlooked public space, away from both the main entrance used by visitors and from car parks.

The qualitative study revealed a range of different strategies employees used to overcome a lack of seating in the direct vicinity of offices. These ranged from bringing folding chairs from home, simply taking office chairs outside on a sunny day, or sitting on a carrier bag on the grass, to using existing structures not intended as seating e.g. the stairs of a fire escape or a wheelchair access ramp.

These findings highlight the utility of locating seating areas in the close vicinity of the buildings, preferably at the back or side of the buildings. They also suggest that the design of science park open space can often fail to communicate transitions between the areas for communal use versus those for use by a particular organisation. Newman's defensible space theory is of relevance in this respect; it describes how design communicates territoriality, classifying spaces into public, semi-public, semi-private and private (Newman 1996). The status of science park open space is complicated in that in some cases the whole site is effectively private space, where public access is denied, whereas others are (or contain areas that are) semi-public. However it is clear that some employees experience confusion over which areas are for use by any employee at the site and which are more private 'territories' of certain companies. Greater attention to designing clear edges and boundaries to mark the transitions between these realms could allow workers greater certainty over the status of particular spaces and seating areas within the public-private hierarchy.

Paths infrastructure

As already noted in section 6.5.1, interview participants' use of the open space was, to a large extent, characterised by physical activity. Participants in the walking interviews

invariably reported their preferred routes as taking the form of a circuit rather than going out and back along linear route. However, the paths infrastructure on the sites sometimes presented challenges to this - one participant at RBC described how when walking a circuit through the adjacent woodland and back on to the site to her building she is forced to cut across open grass, which made her feel self-conscious:

> *"...you do feel a bit stupid because you're not walking on a path and you just think people are probably thinking 'why is she walking across the Biocentre just wandering aimlessly?'"*

A participant at HWURP also commented on an example of a lack of connectivity in the pavements in one area of the site where a pavement ends, forcing pedestrians to cross the road, yet the pavement on the other side is separated from the road by a strip of grass:

> *"Where they've put the strips of paving that go across the grass strip, they don't match up with the paving on the other side. As you can see here you've got to hop off across the grass then onto the path back round to the building. The pavements haven't been thought out when they planned the place, which means on days like today you get your feet wet when you cross the grass."*

The two examples above highlight the importance of considering pedestrian routes and providing a network of paths and pavements linking areas both inside and outside of the site boundaries in the planning of these sites. The importance of access to a coherent network of surfaced paths appears to be particularly salient in the workplace context where the risk of getting clothing wet or muddy can be particularly off-putting with respect to maintaining a professional appearance. Several participants reported concerns about this as something which sometimes discouraged them from using parts of the open space like woodland areas lacking paved paths, particularly when they knew they had meetings scheduled later in the day. Others reported keeping a change of shoes or wellington boots in their car or office, which helped to overcome barriers associated with the risk of getting muddy. The interviews also highlighted a related barrier to use specific to science and technology activities. When working in cleanrooms, where the environment is strictly controlled to avoid contamination, the need to adhere to cleanroom protocol can limit employees' contact with the outdoor environment during the working day, as great care must be taken to keep shoes, clothes and skin clean and particle-free.

6.6.5 Other barriers to use

Although not emerging as common barriers to use in the case study sites, two other potential barriers – access and safety – warrant some further discussion. Although the vast majority of survey respondents do not perceive access to the open space to be an issue in the science park study sites, a small number (approximately 2% of the sample) reported 'lack of easy access to areas I'd wish to use' as something that discourages them from using the open space. The open-ended survey responses and interview data highlighted that this is most relevant for those working in a multiple-occupancy building where their organisation's accommodation is at a remove from the main exit. There were several reports from individuals in different organisations of the use of fire exits to overcome this distance, a practice which was seen to conflict with health and safety policies. Fire exits within individual units also offer opportunities for different practices by acting as a bridge between the indoor office and outdoor environment, allowing occupants to throw open the doors on a good day and benefit from the extra ventilation and sunlight penetration. Also, their location at the back or side of the building meant that they were perceived as being more natural places for colleagues to gather outside than main entrances at the front of buildings. These practices point to the value of incorporating exits at the side and back of buildings in the design, which could include features like screen doors linking individual units to the open space, creating transition zones between the indoor and outdoor workplace environment.

It should also be noted that the accessibility of the open space was expected to be a concern for individuals with disabilities and particularly wheelchair users. It is not, however, possible for this study to comment on this issue as none of the survey respondents or interview participants reported long-term health issues or disabilities as an impediment to their use of the space.

Concern for personal safety is a common barrier to the use of public green spaces particularly for women (Burgess et al. 1988, Ward Thompson et al. 2003). In this study however, safety concerns were not a key factor influencing use of the open space; less than 1% of the survey sample (two female employees) reported this as a factor that puts them off spending time there. This suggests that safety concerns are not the main factor driving the observed gender difference in use of the science park open space. The qualitative study did, however, highlight the importance of lighting in the open space and security measures in promoting perceptions of safety. One female participant at

WSSP reported some discomfort when leaving the office alone after dark due to unreliable lighting in the car park, particularly given the park's proximity to a nearby housing estate and her knowledge of previous issues of vandalism and crime in the area. The visible presence of security personnel and CCTV on the site did, however, help to allay these fears. Security measures were mentioned by others across the case study sites as a reason why they felt safe outdoors at the site after dark. These were particularly relevant for some participants working on sites where animal-related research takes place due to an awareness of the potential risk of being targeted by animal rights protestors.

6.7 Conclusions

Most of the science park workers surveyed reported a high degree of visual access to greenspace from their usual desk or workstation, as discussed in section 6.3. The vast majority (95%) had access to a window, and 73% of these reported finding it very or fairly easy to see out from their desk. Those who only had a window behind them, and those working on the ground floor were more likely to report difficulty viewing out. Visual barriers reported included security measures and desk dividers, and also the necessity of drawing blinds to limit glare on computer monitors. In terms of what employees can see in their view from indoors, the majority (60%) reported a predominately natural view, but this varied significantly between sites, with respondents at HWURP reported the least natural views. Across the sample, the most common view feature was trees (present in 89% of respondents' views), but buildings, roads and car parking also featured in the majority of window views.

The findings on use of the open space, presented in section 6.4, revealed that the outdoor space is used on a regular basis by most respondents; 71% spend time there on at least a weekly basis in summer, with 55% doing so in winter. Most respondents spent less than one hour outdoors at the workplace each week; whilst over 1/3 of respondents spent more than one hour a week outdoors in summer, this fell to 25% in winter. At the individual level, summer and winter use levels are highly correlated, both in terms of the frequency and total duration of use.

Regression analysis (section 6.4.2) highlighted several factors predicting individuals' use levels; the sets of predictors differed depending on whether use was measured in terms of frequency or duration and whether it was summer or winter use that was in question. This suggests that studies measuring use purely in terms of frequency, or

asking respondents to judge their level of use without making seasonal distinctions, may provide only a limited understanding of the factors associated with use of greenspace.

The present study found clear differences between the sexes and between age groups in reported use levels. Women reported using their workplace greenspace less than men (both in terms of frequency and duration), particularly during the winter months. Lottrup et al. (2012) have previously found a similar gender difference in workplace greenspace use, and suggest that this may be partly explained by a greater proportion of women perceiving themselves to be too busy. However in the present study there was no evidence of a gender difference in the influence of time and workload considerations on choices to spend time outdoors. Nevertheless there were some gender differences in the motivations and barriers reported – women were more likely to report motivations for sun/daylight and fresh air, and a greater proportion reported a lack of seating as a barrier.

Workers over the age of 55 were more likely to report low levels of use than those aged 25-54. Getting outside for sun/daylight and social interaction was less of a motivator for those aged over 55, and this may help to explain the lower use levels reported by this group. Those under the age of 25 were more likely than the intermediate age groups to report infrequent use in winter, whereas there was no difference for summer. This age group was much more likely than others to cite sun/daylight and socialising as motivating factors, suggesting that for younger employees the major driver of use is warm sunny weather during summer, when colleagues are most likely to congregate outdoors as a group.

A key factor found to predict use of the outdoor space at work was individuals' participation in outdoor activities during their leisure time; those who regularly came into contact with green outdoor environments during leisure time (e.g. through walking, cycling, visiting parks or gardening) were much less likely to report low use levels, both in summer and winter. This suggests a high degree of spillover in individuals' use of greenspace between the domains of home and work. It also indicates that greenspace at the workplace is more likely to be used to *supplement* outdoor access in other life domains than to *compensate* for a lack of access to green environments from home.

Despite this, there were also indications that the psychological demands of respondents' work acted as a driver to use of the workplace greenspace. Those reporting their job as highly stressful were significantly less likely to report spending less than 30 minutes a

week outdoors around the workplace. Although mental demands were not associated with use levels in the modelling, analysis of stated motivations for use (section 6.5) indicated that a greater proportion of the sample reported attention restoration motives than reported stress reduction/relaxation motives.

Overall, one third of respondents reported restoration-related motivations as primary reasons for spending time outdoors during the working day. In comparison, around two thirds of respondents cited physical activity (mainly in the form of walking) as a primary motivation. This indicated that use of the space was very often active rather than passive, a finding which was supported by the qualitative data. The physical, embodied, benefits of spending time outdoors appear to be of considerable importance in employees' decisions to spend time outdoors; the most common motivations were 'taking a walk/stretching the legs' and 'getting fresh air' (each reported by almost half of all respondents), with 'getting sun/daylight' reported as a key motivation by more than one third of the sample. The importance of these opportunities in influencing choices to go outdoors may reflect strong desires to break from the physical conditions of the indoor environment and the sedentary nature of knowledge-based work.

Both the quantitative survey and particularly the qualitative study allowed insight into the nature of social interactions in the greenspace. The findings indicated that social use of the open space may be driven more by workplace norms than explicit motivations to socialise; whilst around one third spend most of their time outdoors with others, only 10% reported social interaction as a motivation for use. Norms around group participation in physical activities and social lunch and coffee breaks were highlighted in the qualitative study as key influences of use of the open space in the company of others. There were few examples of social interaction between individuals in different organisations - suggesting that the open space may serve to support bonding social capital but less so bridging social capital - and therefore is unlikely to play a part in promoting collaboration and innovation in business activities.

The main barriers to use of the open space reported by respondents were weather/climate and time pressure or workload (section 6.6). The qualitative study findings suggested that the more physical the activities performed were, the less use was conditional upon the weather and temperature. Limitations on the time available for lunch (resulting from high workloads and set lunch periods) were a key consideration in participants' decisions. Most interview participants preferred to spend around 20

minutes or more outdoors when they could. Some took shorter 'booster breaks' outdoors on occasion but social norms prescribing when it is appropriate to take a break, along with personal identities around conscientiousness, strongly limited use of the space outside of the usual break times, unless there was an instrumental reason for leaving the building.

The findings presented in this chapter have a number of implications for the design of the open space on science parks and other campus-style commercial developments. Insufficient seating was reported as a barrier to use by 15% of respondents, with women more likely to identify this as problematic. The walking interviews identified that it is not simply the quantity of seating that can limit passive use of the open space but also the location and qualities of seating areas. Picnic benches appeared to attract more use than benches, as they promote social use during lunch breaks. The most heavily used seating areas fell within what was perceived to be company territory, usually to the side or back of buildings (away from car parks and the main building entrance), whereas seating in more communal and visible areas was less heavily used, partly because workers were not always sure whether they 'belonged' to other organisations and partly because they were more overlooked or exposed to the elements. These findings suggest that providing appropriate seating close to buildings (and shelter from high winds), especially near secondary exits away from car parking areas, and clearly delineating transitions between more public and private spaces through design may help facilitate passive use of the open space (often social in nature).

Also, given that for a substantial proportion motivations for use are geared towards physical activity, design elements supporting walking and more vigorous activities like running are of key importance. Providing a range of short to medium distance routes offering opportunities for shorter and longer walks/runs depending on the time individuals are able to budget may promote active uses. Coherent path networks which link up within the site and integrate with paths in the wider setting are of particular importance, and should be designed to enable users to walk circuits rather than linear routes. Employees may also benefit from information on the routes available and the time required to walk different routes.

Finally, there are trade-offs to be made in the balance between development footprints, building scale and visual and direct access to open space in the design of science parks. Analysis of respondents' visual access to the open space suggests that it may be

worthwhile to eschew traditional single storey building designs. Two storey buildings could allow more employees to benefit from views of the open space, without necessarily blocking out views of mature trees surrounding the site for those in other buildings. Concentrating more floorspace within a smaller building footprint could free up more space to serve as usable open space, away from the extensive car parking areas which are arguably unavoidable in peri-urban business sites.

Chapter 7: Cumulative wellbeing benefits from exposure to workplace greenspace

7.1 Introduction

This chapter presents the findings from investigations into the cumulative wellbeing benefits employees may accrue through exposure to the green environment at the case study Science Parks. These investigations use regression analyses to test for associations between quantitative indicators of workplace greenspace exposure (both views and use) and self-reported wellbeing outcomes, and are thus correlational in nature. All the variables used in these analyses are derived from the employee survey. Three dependent variables are investigated:

1) SWEMWBS metric score – measure of self-reported positive wellbeing calculated from the short 7 item version of the Warwick-Edinburgh Mental Well-being Scale, with raw scores converted to metric scores (Stewart-Brown et al. 2009).
2) Job satisfaction – rating of overall satisfaction with job on a 5 point scale (Very dissatisfied, Dissatisfied, Neutral, Satisfied, Very satisfied).
3) Sickness absences – self-reported number of days of absence due to sickness, ill-health or stress, during the previous 6 months.

The statistical analyses reported in this chapter addresses the following questions:

- Are wellbeing levels, job satisfaction and sickness absence related to: a) window views of nature, and b) use of greenspace at the workplace?
- If so, which is more important – viewing or using the greenspace?
- Do certain view features promote wellbeing benefits and others limit them?
- Does the data from the employee survey allow us to draw any conclusions about the mechanisms behind any observed relationships between workplace greenspace exposure and wellbeing outcomes?
- Does everyone benefit from exposure to greenspace/nature at Science Park workplaces? – i.e. is there any evidence of interactions between independent variables which would indicate systematic differences between individuals or groups in terms of wellbeing effects?

Results of the models exploring associations between greenspace exposure at the workplace and the SWEMWBS variable are presented in sections 7.2-7.6 below. Job

satisfaction and sickness absence variables are investigated in sections 7.7 and 7.8 respectively. Section 7.9 concludes the chapter by synthesising and discussing the findings with reference to the research questions outlined above.

7.2 Associations between exposure to workplace greenspace and employee wellbeing - regression modelling

7.2.1 The outcome variable - SWEMWBS

SWEMWBS is the short (7 item) version of the Warwick-Edinburgh Mental Well-being Scale (WEMWBS). The rationale for selecting SWEMWBS as the primary wellbeing measure is discussed in chapter 5. Development work on the WEMWBS has previously demonstrated that the short 7 item version (see question 36 in Appendix C) overcomes some limitations of WEMWBS in that it is uni-dimensional, largely free of bias, and conforms to the strict criteria of the Rasch model of expected responses for internally valid ordinal scales – indicating that item scores can justifiably be added to calculate a single score summarising a respondent's level of wellbeing (Stewart-Brown et al. 2009). The dimensionality and reliability of SWEMWBS was also tested here using the raw scores of the present study's survey respondents on the seven scale items.

7.2.2 Testing SWEMWBS internal validity and reliability

Brace (2009) advises that it is good practice to analyse the dimensionality and reliability of data from psychological scales since cultural and situational factors may affect the performance of scales in different samples. Initial analysis of the SWEMWBS data therefore assessed the dimensionality of the scale to identify whether it did in fact measure a single psychological construct and was therefore appropriate to combine the items into a single score. A Principal Components Analysis (PCA) (unrotated) was conducted on the 7 SWEMWBS items. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis (KMO=0.865). Field (2009) states that values between 0.8 and 0.9 are 'great', with 0.5 being a minimum threshold for sampling adequacy. Bartlett's test of sphericity ($\chi^2[232]=1064.606$, $p\leq0.001$) indicated sufficiently large correlations between items for performing PCA. The analysis specified extraction of factors with eigenvalues of >1, and this yielded a single-component solution with an eigenvalue of 4.073, explaining 58.2% of the variance. The single factor solution was also confirmed by inspection of the scree plot produced.

Internal consistency was also tested, resulting in a Cronbach's alpha value α=0.875. Values higher than around 0.7 are considered to indicate a reliable scale, in which there is a high level of correlation between individual items (Field 2009, Brace et al. 2009).

This dimensionality and reliability analysis conducted in this study, along with previous studies (e.g. Stewart-Brown et al. 2009) confirmed that the SWEMWBS items are strongly associated with a single underlying (latent) variable – positive wellbeing – and thus are appropriate to combine into a single score for the scale. An additive raw score was therefore calculated as per guidance on the use of the scale (Stewart-Brown and Janmohamed 2008). This raw SWEMWBS score was then converted to a metric scale following published recommendations and conversion values derived from Rasch analysis of the properties of SWEMWBS (Stewart-Brown et al. 2009). This conversion to a robust interval-level variable means that the resultant metric scores conform better to the assumptions of parametric statistical procedures, than do the raw (ordinal level) scores. In cases where values were missing for at least one of the scale items, no overall score was calculated. SWEMWBS scores were therefore available for 323 of the 366 respondents. Of the remaining 43 cases, around half had not completed the full questionnaire so had not reached the SWEMWBS section. Where participants had completed the questionnaire but had missing values on the SWEMWBS question the majority of these had chosen not to complete the scale at all, rather than having omitted values for certain items only.

7.2.3 Workplace greenspace exposure variables

Views and use of the outdoor environment on and around the Science Park study sites was represented using a number of variables. The first set of analysis used the following measures:

- *Use frequency* in the summer months (measured on a 7-point scale from 'never' to 'every day').
- *Weekly use duration* in the summer months (measured on a 6-point scale from 'less than 15 minutes' to 'more than 5 hours' per week).
- *View 'naturalness'* (*natbuilt*) rating of the balance between natural and built features in the window view from respondent's usual workstation, made on a 7-point scale ranging from 'completely built' to 'completely natural'.
- *View satisfaction* (*viewsat*) rating of satisfaction with the quality of the window view from the workstation, on a 5-point scale ranging from 'very dissatisfied' to 'very satisfied'.

The reported use levels during the *summer* months were used because wellbeing (SWEMWBS) was measured during summer (mid-June to early September) and it seemed likely that any impact of exposure to the outdoor environment on wellbeing would arise more as a result of exposures in recent months than total or average exposure over the course of a full year.

In subsequent analyses, view effects were explored further using indicators of the prominence of particular types of features in the window view. Survey respondents reported the proportion of the window area taken up by certain types of features (see table 7.1), which were measured using five response categories of 'not present in view', 'less than ¼', '¼ to ½', '½ to ¾', and 'more than ¾'.

Table 7.1: View feature types measured.

Natural features	Built features	Other features
• Lawn/mown grass • Meadow/rough grass • Trees/woodland • Bushes and flowering plants • Water features • Fields and distant countryside	• Buildings • Footpaths and paved pedestrian areas • Roads and/or car parking • Sculptures, statues or other cultural objects	• Sky

This data provided the following additional view variables:

- *Extent of each feature type in window view*
- *Number of different feature types visible* (an indicator of view complexity)
- *Number of natural feature types visible*
- *Number of built feature types visible*

Questions on view satisfaction, naturalness and view features were only asked of those who responded positively to the question 'do you do the majority of your work at a particular desk or workstation?' and who reported having a window in the room that they work in (n=317). The analysis below therefore only includes employees who are primarily desk-based, who mainly work at a particular desk (rather than hot-desking, which would mean exposure to a greater variety of different views during working time), and who have a window in the room that they work in. Taking into account the cases excluded from the analysis due to missing SWEMWBS score data, this resulted in a total sample size of 286 employees for the modelling.

7.2.4 Controls

To analyse the relationship between exposure to greenspace at work and positive wellbeing level it was important to control for several objective and subjective variables. In the first instance the control variables included a set of individual-level variables to account for socio-demographic factors *gender* and *age* (dummy variables for age brackets used, since the relationship between wellbeing and age was non-linear), socio-economic factors (*income coping* variable, where higher ratings indicate greater difficulty coping on current income), and also whether an individual has experienced any *stressful major life events* in recent months (see section 5.3.3 for further details on the measures used). These variables have been implicated in previous studies as significant predictors of WEMWBS scores specifically, or more generally as influencers of subjective wellbeing/life satisfaction (Diener et al. 1999, Tennant et al. 2007, Bradshaw et al. 2012), and therefore it was important to control for these potential sources of variation in wellbeing variables.

Two variables representing the extent of alternative opportunities for nature restoration during leisure time were also included; these were *frequency of outdoor leisure activities* (e.g. walking/hiking, running, cycling, gardening, visiting parks and woodlands etc., outdoor sports, and nature-based hobbies) and whether there is *access to a private garden* at the home. These were included in the model specification to avoid any spurious associations between workplace greenspace exposure and wellbeing arising because of workplace greenspace use levels acting as a proxy for use of greenspace in leisure time.

A final set of controls related to work characteristics and the working environment. Dummy variables for the *study sites* were included (as these vary in terms of their geography, character, and constituent companies; with some sites being specialist hubs for particular industries). The effect of indoor environmental variables on employee wellbeing and functioning is well established (Vischer 2007), and spending more time outdoors could also be a result of discomfort indoors, so it was considered important to control *satisfaction with indoor environment* in the analysis. A variable was included for working hours - *full-time,* as opposed to part-time – since some previous studies indicate that this may be an important factor in ratings of job satisfaction, and some measures of subjective wellbeing (particularly for women), although evidence on this is mixed (Booth and Van Ours 2007, Gash et al. 2009, ONS 2012a). To address the over-

representation of organisations with an environmental protection or management remit, a variable (*envwork*) was also included. It was hypothesised that involvement in this type of work might affect the relationship between greenspace and wellbeing, and previous research has found those who have a greater affinity with nature (which we might speculate to be the case for many of in environmental sector work) also display higher wellbeing levels (Howell et al. 2011, Cervinka et al. 2012). Finally, two variables measuring job demands were also included (*mental demands* and *job stress*), along with dummy variables representing job type, since each of these factors could plausibly impact on employee wellbeing.

In order to create a more parsimonious model several of these control variables were omitted when it became clear they were not contributing significantly to the model. Those that remained in the model were: *gender*, *age 16-24*, *WSSP site* dummy, *income coping*, *outdoor activities frequency*, *job mental demands*, *job stress* and *satisfaction with the indoor environment of the workplace*. Removal of the other variables which were initially controlled did not alter the relationships between the dependent and independent variables in any meaningful way. The results of this more parsimonious model are reported below.

7.2.5 Initial model results

Multiple regression analysis on the SWEMWBS outcome variable was conducted using PASW Statistics v18, with open space variables added to the controls-only model in blocks. The results of the analysis are summarised in table 7.2. Assumptions for linear regression modelling were met, with the plot of standardised residuals vs. standardised predicted values showing no indication of either non-linear relationships between the dependent and independent variables or of heteroscedasticity. Inspection of the normal probability plot confirmed the normal distribution of the error term. Tolerance and VIF statistics confirmed the absence of multicollinearity amongst the independent variables. The model output is shown in Appendix H.1.

The controls-only model (block 1) significantly predicted SWEMWBS score (ANOVA: F=8.352, p=0.00) and explained 15.9% of the variance in the dependent variable. Adding the variables use frequency and use duration (block 2) increased the model fit (explaining 17.6% of the variance in SWEMWBS) however neither of the use variables were significant predictors at this stage. It is only when both use and view variables are included in the model (blocks 3 and 4) that significant relationships emerge. The full

model in block 4 again predicts SWEMWBS adequately (ANOVA: F=7.048, p=0.00), and explains 21.1% of the variance. This model shows significant positive relationships between use duration and SWEMWBS ($p \leq 0.05$) and also between view satisfaction and SWEMWBS ($p \leq 0.01$).

Table 7.2: Open space variables as predictors of SWEMWBS score in OLS regression modelling. Significant associations shown in bold.

	Block 1: Controls only		Block 2: Adding use variables		Block 3: Adding natbuilt		Block 4: Adding viewsat	
	ß	p	ß	p	ß	p	ß	p
Use frequency	-	-	0.068	0.287	0.047	0.496	0.023	0.732
Use duration	-	-	0.096	0.126	**0.147**	**0.028**	**0.155**	**0.018**
View naturalness	-	-	-	-	0.071	0.210	-0.013	0.824
View satisfaction	-	-	-	-	-	-	**0.233**	**0.000**
Model fit	Adj. R^2=0.159		Adj. R^2= 0.176		Adj. R^2= 0.172		Adj. R^2=0.211	

This analysis suggests overall that, controlling for other factors listed in section 7.2.4, those who use the open space around their workplace for a longer total time over the course of a week report higher wellbeing levels. Also, the higher an employee's satisfaction with the quality of the window view from their usual workstation, the higher their wellbeing level.

There is no evidence here of any relationship between use ***frequency*** and wellbeing. Whilst those who report using the open space for smoking spent time outdoors more frequently (Mann Whitney U test: Z=-2.680, p=0.007), adding smoking as a control variable in the model did not alter this result. Neither is there any association between view naturalness (measured on a 7-point scale from completely built to completely natural) and wellbeing. The absence of significant associations for these two open space variables goes against expectations. Previous large-scale studies have found relationships between greenspace use frequency, stress-related illnesses and risk of poor mental health (Grahn and Stigsdotter 2003, Mitchell 2012), however issues relating to the amount of time spent in a restorative environment is usually only been considered in relation to discrete exposures to greenspace (e.g. Hartig et al. 2003, Ryan et al. 2010). The findings presented here suggest that, where available, the total amount of time spent in greenspace may be a more useful measure of use levels in respect to mental health and wellbeing than use frequency. The lack of association between the view naturalness variable and wellbeing indicates that measures conceptualising scenes as lying on a

continuum of built to natural may be insufficient to capture the wellbeing effects of nature in quantitative research. The following section discusses this further.

7.3 Exploring the effects of window view

7.3.1 Objective view features

A further model was created to test for associations between the prominence of different types of natural and built features in the window view and the wellbeing outcome. The predictor variables entered into this model were: use duration, each of the view feature types listed in table 7.1 (extent of buildings/trees/water etc. in view), and the restricted set of control variables used in the modelling reported above in section 7.2.5. The resultant model complied with the assumptions of OLS regression, predicts SWEMWBS adequately (ANOVA: F=4.987, p=0.00), and explains 29% of the variance. The standardised coefficients and significance values for each of the view feature types are shown in table 7.3.

Table 7.3: Modelling associations between objective view features and SWEMWBS scores. Significant associations shown in bold.

	ß	p
Sky	0.060	0.381
Buildings	0.038	0.591
Fields and distant countryside	-0.004	0.963
Water features	-0.001	0.987
Lawn/mown grass	**0.195**	**0.039**
Meadow/rough grass	0.123	0.170
Trees/woodland	**0.207**	**0.002**
Bushes and flowering plants	0.140	0.052
Paths and paved areas	0.016	0.887
Roads and car parking	-0.097	0.295
Sculptures, statues or other cultural objects	0.034	0.640
Model fit		Adj R^2=0.290

Trees/woodland ($p \leq 0.01$) and lawn/mown grass ($p \leq 0.05$) are both significantly and positively related to SWEMWBS scores. Bushes and flowering plants show a marginally significant positive association, with significance falling just outside the 5% threshold. These findings are in line with previous research indicating that the restorative potential of an open space is predicted most strongly by its structural vegetation - grass (ground layer), trees (canopy) and bushes (shrub layer) (Nordh et al. 2009, Nordh et al. 2011). The apparent positive effect of mown lawn on wellbeing does, however, contrast with Matsuoka's (2010) finding of a negative association between mown grass areas in school grounds and educational and behavioural outcomes.

None of the built features were found to relate to wellbeing. This is in line with previous research on associations between aspects of wellbeing and window view features in the residential context (R. Kaplan 2001). This finding is interesting in that it suggests that whilst viewing some types of natural feature promotes wellbeing benefits, this does not automatically mean that viewing built features limits the potential for these benefits. In other words, it seems that it is the presence (and extent) of types of vegetation in the view that is important here, not the absence of development. This finding also goes some way to explaining why no association was found with the view naturalness variable in the previous models; it seems that conceptualising views as lying on a continuum of built to natural results in an overly crude measure of 'naturalness' which does not reflect the distinct influences of natural and built environmental stimuli.

Another important aspect of these findings is that not all of the features classed as natural were found to be related to wellbeing. The lack of an impact of viewing water features was unexpected given the literature suggesting that viewing (and hearing) water features promotes restorative experiences (White et al. 2010, Karmanov and Hamel 2008, Völker and Kistemann 2011). However this finding may be due to the fact that less than 5% of those who answered the question about what they could see in their window view reported seeing water, limiting robust measurement of the predictive power of this factor. Similarly, few reported seeing sculptures, statues or other cultural artefacts in their view. The finding that viewing fields and distant countryside, and meadow/rough grass appear to have no effect on wellbeing can be treated with more confidence however, as in each case more than a quarter of respondents reported these as present in their view.

7.3.2 Relative impact of view features and use of workplace open space

Inspection of the standardised beta coefficients in table 7.3 suggests that of the view feature types, trees/woodland appears to have the largest effect size, followed by lawn/mown grass and then bushes and flowering plants. To further investigate the relative effects of view contents and open space use, the view features with significance values greater than p=0.1 were removed from the model. The resulting model explained a substantial 32.1% of the variance in SWEMWBS. The coefficients for each of the remaining open space exposure variables are shown below in table 7.4, with the full model included in Appendix H.3.1. The model shows that the standardised effect size of each of the significant vegetation variables exceeds that of use duration, with extent

of trees in view having the greatest impact on wellbeing, closely followed by lawn/mown grass, and bushes and flowering plants. This suggests that what employees see in their workplace window view influences their wellbeing to a greater extent than the amount of time they spend outside in the greenspace itself. Previous studies that have considered both use and views of workplace greenspace have combined these into a single index (see section 3.2.2). By examining these two forms of exposure to workplace greenspace separately the present study goes beyond supplying evidence of the restorative value of workplace greenspace, towards building an understanding of how these different forms of exposure relate to wellbeing outcomes. The implications of this distinction are important for planning and design of sites, as it suggests that building design and landscaping considerations should be strongly integrated from the early stages of design. Designing buildings to maximise views to the surrounding green setting, and (where appropriate) augmenting the landscape structure of spaces that are highly visible from indoors, could help to capitalise on the potential wellbeing benefits of open space on business sites.

Table 7.4: Relative impact of open space exposure variables significantly predicting SWEMWBS.

	ß	p
Use duration (summer)	0.124	0.039
Extent of trees/woodland in view	0.207	0.000
Extent of lawn/mown grass in view	0.206	0.001
Extent of bushes and flowering plants in view	0.201	0.001
Model fit		Adj R^2=0.321

7.3.3 Heterogeneity of view content

In reducing views down into their constituent features in analysis such as that presented above there is a danger of overlooking the potential impact of the interaction between the individual stimuli viewed. Views are more than simply a sum of their parts; the way an environment is perceived, and the feelings that are generated during the experience, are likely to be products of a more subtle interplay of the full range of stimuli on hand. Perception studies have demonstrated the importance of emergent properties such as complexity, coherence, mystery, openness, and visual access in the way we respond psychologically to our environment (Kaplan and Kaplan 1989, Kaplan 2007, Herzog et al. 2003). Although this study is limited in the extent to which the perception of such properties can be captured in the quantitative analysis, there was opportunity to examine the impact of complexity in terms of the heterogeneity or number of different visual elements in the window view. In order to examine whether seeing a greater variety of different elements in the workplace window view contributes towards wellbeing (over

and above the individual significant vegetation variables trees, lawn and bushes/flowering plants) the variable representing the number of different feature types visible was added to the model summarised above in table 7.4. The complexity/heterogeneity of view variable was not significantly associated with the SWEMWBS outcome variable. When the number of natural and built features in view were represented in two separate variables, replacing the complexity variable, again no effect was found. Model output is available in Appendix H.2.

7.4 Exploring the role of view satisfaction as a mediator

The results presented so far in this chapter have demonstrated that in separate models, both subjective (view satisfaction) and objective (view contents) factors are associated with employee wellbeing. This raises the question: are the view elements trees/woodland, lawn/mown grass and bushes/flowering plants related to wellbeing simply because people like to see these features in their window view? This question was explored through the use of mediation analysis.

Mediation analysis (Baron and Kenny 1986) is used to test the hypothesis that the independent variable(s) of interest is related to the dependent variable through its effect on a third 'mediator' variable, assuming causal links between the variables. Mediation analysis therefore provides a method for exploring how much of the apparent positive effect of viewing these vegetation types may attributable to an indirect effect whereby seeing more trees/lawn/bushes results in higher view satisfaction (path *a* in fig. 7.1) which in turn has a positive effect on wellbeing (path *b*), as opposed to a direct relationship between the independent and dependent variables (path *c*).

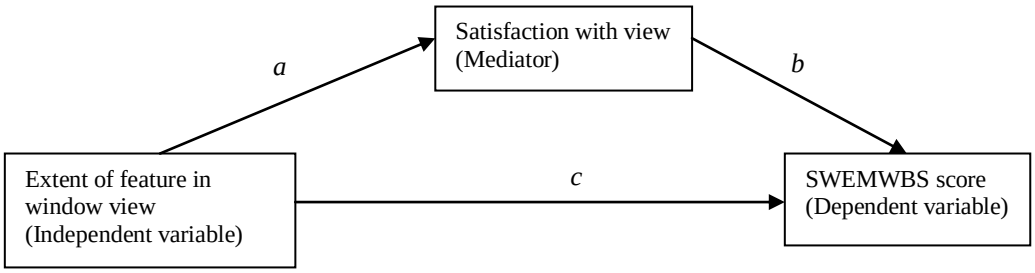

Figure 7.1: Proposed mediation relationship

To test for mediation, three regression models were required (Baron and Kenny 1986). In the first model (model 1) the independent variables (trees/woodland, lawn/mown grass, and bushes/flowering plants) were entered as predictors of the dependent variable

(SWEMWBS score). In model 2 the independent variables were entered as predictors of the potential mediator variable (view satisfaction). Finally in model 3, the independent variables (trees/woodland, lawn/mown grass, and bushes/flowering plants) and the mediator variable (view satisfaction) are entered as predictors of the dependent variable (SWEMWBS). Each of the three models also included the set of control variables used previously. The model output is included in Appendix H.3.

There are four analytical steps involved in establishing mediation (Kenny 2012). These are:

1. *Show that the independent variable(s) are significantly related to the dependent variable.*

   This was established with reference to model 1. The proportion of the view composed of trees/woodland was significantly related to SWEMWBS (ß=0.207, $p<0.01$), as was lawn/mown grass (ß=0.206, $p<0.01$) and bushes/flowering plants (ß=0.201, $p<0.01$).

2. *Show that the independent variables are significantly related to the mediator variable.*

   Model 2 showed that trees/woodland was significantly related to view satisfaction (ß=0.224, $p<0.01$), as were lawn/mown grass (ß=0.208, $p<0.01$) and bushes/flowering plants (ß=0.199, $p<0.01$).

3. *Show that the mediator variable is significantly related to the dependent variable, controlling for the independent variable(s).*

   Model 3 demonstrated this not to be the case. View satisfaction, though previously found to predict SWEMWBS in the initial modelling reported above in table 7.2, no longer predicted SWEMWBS when the view features trees, lawn and bushes/flowering plants were controlled (ß=0.101, $p>0.05$).

4. *Assess mediation by examining the residual effect of the independent variable(s) on the dependent variable, when controlling for the mediator variable. Full mediation is indicated when the effect of the independent variable(s) is not significantly different from zero. When a significant effect remains, this indicates partial mediation.*

   In model 3 the effect of the independent variables trees/woodland, lawn/mown grass and bushes/flowering plants each remained significant predictors of SWEMWBS whilst controlling for view satisfaction. The criteria for mediation were not met (since in model 3 view satisfaction was no longer a significant

predictor of SWEMWBS), yet this suggests that there is a clear direct relationship between the independent view feature variables and SWEMWBS.

It was considered a possibility that the lack of association between view satisfaction and SWEMWBS in model 3 could have been a result of a large amount of the variance in view satisfaction being explained by the three view features entered into the model. This was explored further using two methods: a) by calculating an index of the three view feature variables and inspecting output for evidence of collinearity with view satisfaction; and b) by modelling the effects of the three view feature variables on view satisfaction in the absence of the other control variables. Both methods provided little evidence to support this hypothesis. There was no overt collinearity between the view features index and view satisfaction, and when modelled as the sole predictors of view satisfaction the view features trees, lawn and bushes accounted for only 16% of the variation. It therefore appears that, rather than affecting SWEMWBS through subjective satisfaction, these view features had a more direct relationship with SWEMWBS. Indeed, it appears that viewing trees, lawn and bushes/flowering plants explained the relationship between view satisfaction and wellbeing previously observed, rather than view satisfaction explaining the relationship between the objective view features and wellbeing.

This analysis suggests that an unobserved psychological variable(s) must mediate the relationship between objective view features and wellbeing. This is an area which may warrant further research along the lines of the methods previously used by Frances Kuo and colleagues, where objective measures of attentional functioning and stress levels were investigated as mediators in the relationships between outdoor residential greenery and psychological outcomes such as levels of aggression and individuals' efficacy in managing major life issues (Kuo and Sullivan 2001, Kuo 2001).

7.5 Does the context of use impact on the relationship between use and wellbeing?

7.5.1 Causation considerations

The relationship found between use duration and employee wellbeing (table 7.2) is consistent with expectations based on restorative environments theory (see section 2.2) and empirical studies demonstrating associations between greenspace use and measures of mental health and stress-related conditions (e.g. Grahn and Stigsdotter 2003, Mitchell

2012). Cross-sectional studies cannot, however, demonstrate causal effects to the same degree as controlled experiments. This issue is particularly relevant in terms of the relationship found between use (duration) levels and employee wellbeing. It is possible that the direction of the relationship runs contrary to that which we would expect from restoration theory, i.e. that rather than greater use of the greenspace resulting in higher wellbeing, higher wellbeing results in greater use of the greenspace. However, the strong relationships between greenspace in window views and wellbeing lend some support to the hypothesis of a causal relationship where use influences wellbeing. After all, wellbeing levels cannot influence the content of the window view, and there is no indication that self-selection plays a part as evidence from both the open-ended questions in the employee survey and walking interviews suggests that for the most part employees on the case study sites have limited choice as to where they sit in their office or laboratory and therefore the view that they have.

7.5.2 Investigating social interaction, physical activity and restoration motives as moderators of wellbeing benefits

Another possible interpretation of the relationship between workplace greenspace use and wellbeing is that there may be a mechanism other than psychological restoration which accounts for this finding. It might be that greater use of the greenspace influences wellbeing through increased physical activity or social interactions, or both. This possibility was explored through moderation analysis, aiming to ascertain whether those who use the space for either social or physical activities, or with the explicit motivation of psychological restoration (relaxing and getting away from work hassles, or clearing the head/ regaining focus) experience greater benefits than others.

Standard procedure for moderation analysis (testing for interaction effects) was carried out (Aiken and West 1991). The independent variables initially entered into the model were (for the sake of parsimony) confined to the significant greenspace exposure variables use duration, and proportions of view composed of trees, lawn and bushes/flowering plants, along with those control variables found to be significant or marginally significant predictors of SWEMWBS score in the initial model reported in section 7.2.5 (gender, age, income coping, WSSP site, outdoor activities frequency, job mental demands, job stress, satisfaction with indoor work environment). To this, two further independent variables were added:

a) the potential moderator variable denoting whether or not the respondent reported using the open space for reasons of physical activity (*motPA*), socialising (*motsoc*), or restoration (*motrest*); and

b) an interaction term representing the interaction between use duration level and the activity in question.

The interaction term was calculated as a product of the use duration and the activity variables. The use duration variable used in these models (*CenUDsum*) was centred to avoid collinearity with the interaction term (Aiken and West 1991). All models conformed to the assumptions of linear regression models. In addition, the same procedure was followed to test for any moderating effect of the social context of use, which was represented by a categorical variable distinguishing between those that reported mainly using the open space with others and those that mainly use it alone (*Socuse*). The standardised coefficients and significance values for the interaction effects in each of the four models are shown in table 7.6.

Table 7.6: Testing for moderating effects of use context on the relationship between use duration and wellbeing. Values significant at the 5% level shown in bold.

Potential moderator variable	Interaction term coefficients	
	ß	p
Socuse	**-0.186**	**0.029**
Motsoc	-0.099	0.097
MotPA	-0.045	0.644
Motrest	0.013	0.846

Social interaction

Table 7.6 shows that social context of use (socuse) is a significant moderator of the relationship between use duration and SWEMWBS (see also Appendix H.4). This was explored further using ModGraph, a moderation analysis visualisation tool which performs the necessary calculations (described in Aiken & West [1991]) to plot interaction effects (Jose 2008). The graphical output from ModGraph is shown in figure 7.2. Similarly, there is a marginally significant moderating effect of using the open space because of the motivation for socialising or chatting to colleagues (table 7.6).

Figure 7.3 shows that only those that tend use the open space alone show a positive relationship between use levels and SWEMWBS. Those who are more prone to spending time in the open space in company have higher wellbeing levels overall regardless of use level, but display no evidence of any wellbeing benefits from using the space. In fact there appears to be a slight negative association between use and

wellbeing for this group. Therefore, although those that are perhaps more sociable or have greater social capital tend to have higher wellbeing, consistent with previous research (De Silva et al. 2005, Islam et al. 2006, Dolan et al. 2008), the wellbeing gap between those who tend to use the space alone and those that do so with others is reduced with higher levels of greenspace use.

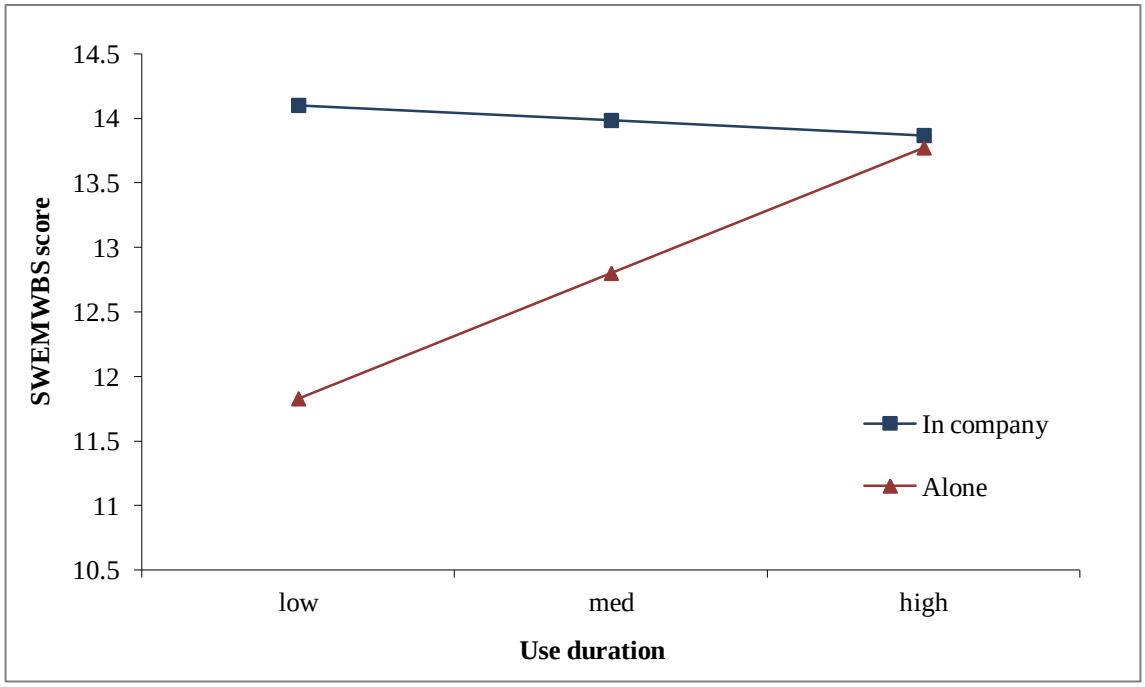

Figure 7.2: Moderating effect of social context of use on the use-wellbeing relationship.

These findings demonstrate that the apparent positive effect of spending more time in workplace open space on wellbeing is not due to increased levels of social interaction, since for those who use the open space in the company of others greater use is not related to higher wellbeing. This is consistent with a restoration perspective which suggests that where feelings of safety are not in question, greater benefit is derived from solitary use of natural environments as this is more conducive to peaceful contemplation, reflection and attention to the surroundings (Staats and Hartig 2004, Korpela et al. 2008, Johansson et al. 2011). This finding has important implications for workplace walks initiatives seeking to promote both physical and mental health amongst employees. It is possible that a richer, more fascinating environment than those in and around the case study sites may be necessary for cumulative *restorative* benefits to be gained through group walks, although group walks may still promote wellbeing if they increase social capital and/or if they motivate individuals to spend more like outdoors alone in addition to participating in group walks.

Physical activity and motives for restoration

Overall this series of moderation analyses provides no evidence that either physical activity or social interaction are the primary mechanisms behind the relationship between workplace greenspace use and employee wellbeing. Using the space for physical activity does not appear to offer enhanced wellbeing benefits (there is no interaction effect), and using it for social interaction appears to limit the added benefits of spending time in the open space. Neither is there evidence implicating restoration as the primary mechanism however; there is no moderating effect of using the open space explicitly for restoration. Therefore, although the moderation analysis reported in this section indicates that social interaction does not explain the relationship between use and wellbeing, it does not identify which other mechanisms are responsible for this effect.

7.6 Does everyone experience wellbeing benefits from exposure to workplace greenspace?

7.6.1 Using moderation analysis to investigate group and individual differences in wellbeing benefits

This section presents the results of moderation analyses aiming to explore factors which might impact the extent to which individuals' wellbeing is promoted by exposure to workplace greenspace at science parks. The method followed here mirrors that used in the previous section. As a starting point, the open space exposure variables (use duration, extent of trees, lawn and bushes/flowering plants in view) were entered as predictors of SWEMWBS score, controlling for the relevant socio-demographic, socio-economic and work-related covariates used in previous models. To test for interaction effects, a series of models were run which included these predictors, along with the potential moderator variable of interest and the interaction term calculated as a product of the moderator variable and the greenspace variable. This was repeated to test for interactions with each of the four greenspace variables. Non-categorical variables were centred to avoid collinearity issues.

This procedure was carried out using a number of potential moderating factors listed in table 7.6. Previous population studies have indicated interaction effects of gender (Richardson and Mitchell 2010) and socio-economic factors (Mitchell and Popham 2008). Studies of discrete psychological effects of greenspace exposure and of

perceived restorative potential suggest that latent needs for restoration (experiencing stress, mental fatigue or poor mental health overall) affect the magnitude of positive effects (Hartig and Staats 2006, Morita et al. 2007, Korpela and Ylén 2007, Roe and Aspinall 2011a), and that the level of familiarity with the place or type of place in question may also influence perceived restorativeness (Purcell et al. 2001, Berto 2007). Each of these factors were explored as potential moderators of the relationships between workplace greenspace exposure and employee wellbeing, along with working hours (whether full-time or part-time) and the variable designating environmental sector workers (whether or not respondents work in an organisation focusing on environment or land-management interests). The coefficients for each of the interaction terms are shown in table 7.6.

Table 7.6: Testing for moderating effects of group and individual differences on the relationships between workplace greenspace exposure variables and SWEMWBS. †p≤0.10,*p≤0.05, **p≤0.01

Potential moderators	Interaction term standardised coefficients (ß)			
	Use duration	Trees in view	Lawn in view	Bushes and flowering plants in view
Gender (female)	0.051	-0.002	0.103	0.186
Difficulty coping on income	0.056	0.008	-0.061	-0.029
Working hours (full-time)	0.193	-0.003	0.141	-0.055
Environmental sector	-0.168*	0.038	-0.185**	-0.185**
Job mental demands	0.005	0.081	0.009	0.027
Job stress	0.061	0.043	0.109†	0.119*
Length of time working at site	-0.041	0.042	-0.044	0.105†

For the most part the potential moderators were not seen to interact significantly with any of the greenspace exposure variables. Environmental sector work does however appear to act as a moderator; it has significant interaction effects on the associations between use level and wellbeing, and between lawn in the window view and bushes and flowering plants in the view, and wellbeing. This is discussed further below. Model output for this analysis is shown in Appendix H.5.1. There are also indications of a moderating effect of job stress. This is only significant for bushes and flowering plants in view, but the coefficient also approaches significance (p=0.069) for lawn in view. Model output is available in Appendix H.5.2.

Environmental sector workers

The key finding in this moderation analyses is that working in the environmental sector interacts with three of the four greenspace exposure variables in their association with SWEMWBS. Within the full sample of respondents to the employee survey, those in environmental organisations were overrepresented, likely due to an increased interest in

the subject area. It was therefore considered important to examine whether there is a difference between these workers and others who work in different sectors in the effects of workplace greenspace. There are indications from the literature that those with stronger pro-environmental values and nature-orientedness are associated with higher perceptions of restorative potential in natural environments (Hartig et al. 2001, Korpela et al. 2008). It was expected that this may have resulted in those working in environmental organisations displaying greater wellbeing benefits from exposure to workplace greenspace than others. Indeed, as shown in table 7.6 there were significant interaction effects indicating that for three of the independent variables, their relationship to SWEMWBS differed between environmental sector workers and others. However on exploring this interaction effect it was seen that, against expectations, those in environmental work *did not benefit* from increased use of the open space, nor increased amounts of lawn and bushes/flowering plants in their window view, whereas others did. Figure 7.3 illustrates this interaction. There is a positive linear relationship between use duration and wellbeing for those in the 'other' category, whereas for those in environmental organisations greater use of the open space is in fact associated with *lower* wellbeing. The same pattern existed for both extent of lawn/mown grass and bushes/flowering plants in view. The exception is the association between trees in view and wellbeing. There were no interaction effects of environmental work on this relationship, indicating that regardless of whether respondents worked in environmental organisations or not, seeing more trees in the window view related to higher wellbeing.

One possible interpretation for the moderating effect of working in an environmental sector organisation relates to perceptions of biodiversity. Recent work by Dallimer et al. (2012) has found that whilst *actual* biodiversity of urban greenspaces were not consistently related to self-reported psychological benefits experienced during a visit, *perceived* levels of biodiversity (which may not be at all accurate) were.

It may be that many of those working in the environmental organisations on the case study sites have, through their work and/or their educational background, enhanced ecological knowledge. This could result in them perceiving lower levels of biodiversity in the landscaped open space of their site, and therefore do not experience the same psychological benefit as those who have less environmental knowledge. The finding that working in the environmental sector interacts with mown grass and bushes/flowering plants in the window view, but not with trees may support this interpretation. Whilst for some a 'natural' window view of mown grass and shrubs

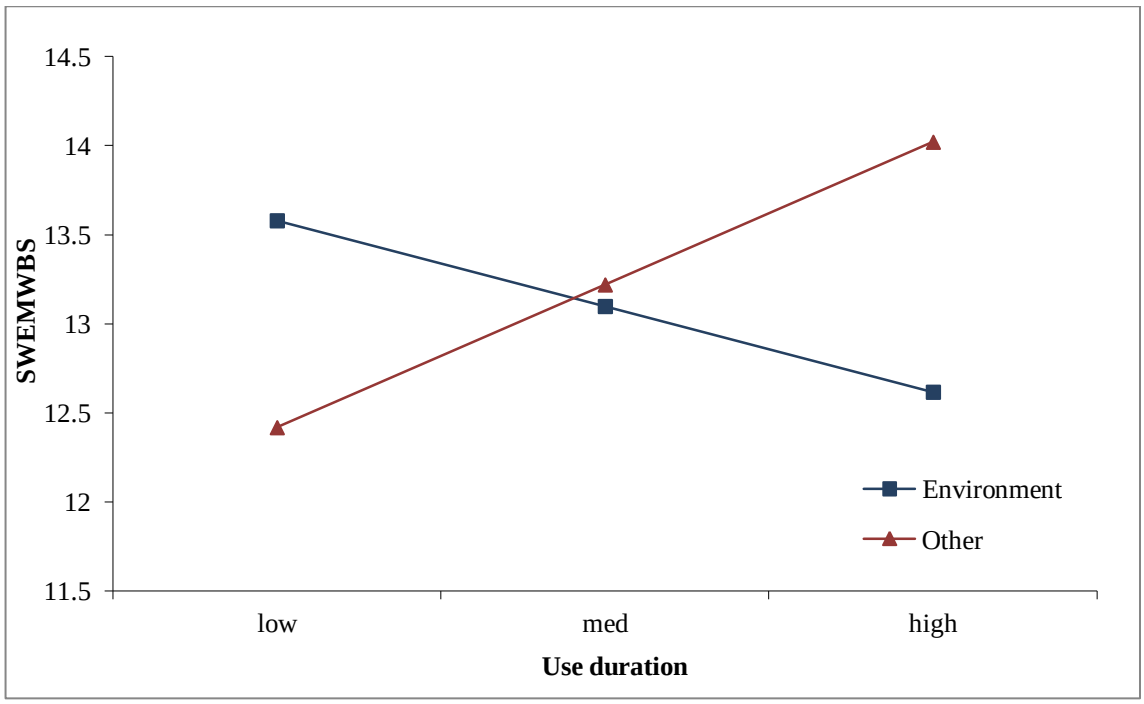

Figure 7.3: Moderating effect of environmental sector work on the use-wellbeing relationship.

(often exotic) may perhaps seem supportive of biodiversity, those who recognise the limited ecological value of such vegetation may perceive these spaces to be lower in biodiversity value, limiting the potential for wellbeing benefits from viewing them. This interpretation is discussed in greater depth in chapter 8 in relation to the findings from the qualitative interviews with science park employees.

Job stress

There is also some evidence pointing towards interaction effects of job stress on benefits gained from viewing certain vegetation types in workplace window views. Table 7.6 shows that individuals' ratings of how stressful their job is moderate the relationship between viewing bushes/flowering plants and employee wellbeing, and there is also some evidence of a marginal interaction with lawn/mown grass. The significant interaction with bushes/flowering plants is illustrated in figure 7.4. The positive effect of bushes and flowering plants in the window view appears to be strengthened as job stress increases, as indicated by the steepening slope of the linear relationship. This finding is in line with restoration theory which suggests that the greater the need for restoration is (in this case an increased need for stress relief), the greater the magnitude of benefit an individual will derive from exposure to a natural environment. However, it is not clear why this significant interaction was found in the case of bushes and flowering plants but not for the other greenspace exposure variables.

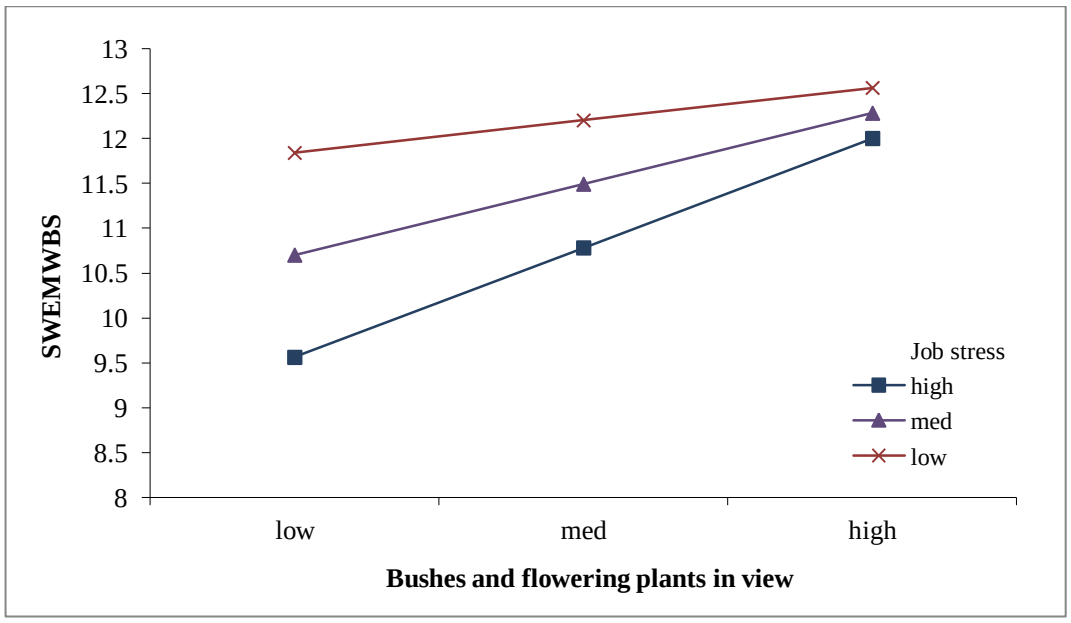

Figure 7.4: Moderating effect of job stress on the relationship between bushes and flowering plants in window view and SWEMWBS.

7.7 Job satisfaction regression modelling

Ordinal (ordered logit) regression modelling was carried out to examine relationships between the greenspace variables, control variables (as listed in section 7.2.4) and the ordinal-level dependent variable job satisfaction rating. Ordinal regression modelling is more appropriate than OLS where the outcome variable has ordered categories, as this model does not assume equal intervals between the response categories (Long 1997). Analysis was performed using the PLUM (Polytomous Universal Model) programme in PASW Statistics.

Given previous research indicating positive effects of green views on job satisfaction (Kaplan 1993, Shin 2007), it was expected that natural view features would be significantly associated with job satisfaction ratings. Although previous research provides limited evidence of positive effects of use of greenspace on job satisfaction (Lottrup et al. 2012) it was hypothesised that, given that the present analysis would account for both use and views of greenspace, a significant effect of use on job satisfaction would be found. Given the results of the SWEMWBS modelling, use duration was expected to have a greater effect than use frequency. However, despite the expectations of significant effects of views and use of the workplace greenspace, other variables relating to job demands and satisfaction with the indoor working environment were expected to have a stronger effect on job satisfaction than the outdoor environment.

Job satisfaction was measured on a five point Likert scale from 'very dissatisfied' to 'very satisfied'. In the first instance the full set of control variables was included, with age represented by dummy variables for the 16-24 and 55+ years age categories included since these groups had higher job satisfaction scores on average than the intermediate age groups. The open space variables initially entered into the model were, as previously, use frequency (summer), use duration (summer), view naturalness (on a scale from 'completely built' to 'completely natural') and view satisfaction. The control variables found to be unrelated to job satisfaction were removed from the model and the calculation repeated.

The resultant model was a significant improvement on the intercept-only model (χ^2=85.611, p=0.00), the test of parallel lines (χ^2=55.399, p=0.003) indicated that the assumption of parallelism (i.e. that odds are proportional across the partitions of the dependent variable) was not satisfied. However, where the focus is (as in this study) simply on determining *whether there is an effect* of the independent variables on the dependent variable, rather than examining the odds ratios between the levels of the outcome, the model can still be used as the results give a weighted average effect across the cut points (McVie and Shephard 2010).

The model predicted around 28-30% of the variance in job satisfaction ratings. The model coefficients (included in full in Appendix H.6.1) indicated that there was a marginal positive association between use duration (the total average time spent outdoors around the workplace during the course of a week) and job satisfaction ratings (p=0.074). However, there was no evidence of effects of use frequency or of view naturalness or satisfaction on job satisfaction. As hypothesised, the strongest predictors of job satisfaction were the job-related variables for job demands (ratings of how mentally demanding and how stressful their work is, both p<0.01) and satisfaction with the indoor environment of the workplace (p<0.01).

A second model repeated this procedure, this time replacing the view naturalness and view satisfaction variables with the set of variables representing the extent of the view formed by the eleven view feature types listed in table 7.1 (e.g. trees, buildings, lawn etc.) Non-significant control variables were again removed. This model explained a greater proportion of the variance in job satisfaction ratings than the previous model (around 40-43% now explained). Again the model was a significant improvement on the intercept only model (χ^2=95.592, p=0.00). The test of parallel lines indicated again

that odds were not proportional across the different levels of the job satisfaction variable (χ^2=97.333, p=0.004). The model coefficients are included in full in Appendix H.6.2.

This improved model including window view feature types showed a clear positive relationship between workplace open space use duration and job satisfaction ($p<0.05$). Again there was no association for use frequency. Of the view feature types, only the bushes and flowering plants variable was associated with job satisfaction ($p<0.05$).

Overall, the results of the job satisfaction modelling indicate that those who spend more time in the open space at their workplace also experience greater job satisfaction. This corresponds with the positive association between use duration and employee wellbeing. However, there is much less evidence of an effect of views on job satisfaction than wellbeing. Satisfaction with the quality of the window view is not related to job satisfaction, and only seeing more bushes and/or flowering plants in the office window view is associated with higher job satisfaction. This was unexpected, given the strong relationships found between view variables and wellbeing in previous models, and evidence of associations between view satisfaction, view nature and job satisfaction in the literature (Kaplan 1993, Shin 2007). It is not clear why views of bushes and/or flowering plants appear to promote job satisfaction in science parks whereas other vegetation types such as trees do not.

7.8 Sickness absence regression modelling

The potential effect of exposure to greenspace at the workplace on employee absence rates was also investigated. The dependent variable used was the self-reported number of days absent from work due to sickness, ill-health or stress in the last six months (with extreme outliers removed). Since this period covered summer and winter months, new variables for use frequency and use duration were calculated to approximate the total number of occasions per year on which the open space was used (*UFyearcount*) and the total number of hours spent there over the course of a year (*UDyearcount*). These were included as independent variables along with view variables and the control variables used in previous models.

Multiple linear regression using ordinary least squares (OLS) method was performed, however the model assumptions of normality of the error term and of homoscedasticity were violated. The sickness absence variable was positively skewed, with the majority of respondents reporting zero days taken off sick. Following advice in Tabachnick and

Fidell (2001), logarithmic and inverse transformations were applied to the sickness absence variable. Model assumptions were still not met in either case, so binary logistic regression was used henceforth.

In the UK the average absence rate is 4.5 days per year (ONS 2012b). A binary dependent variable was created which distinguished between respondents who had taken more or fewer than the average number of days, adjusted for a six month period. All of the predictors entered into the model were binary categorical variables, with dummy variables created where appropriate. The workplace open space variables initially entered consisted of dummy variables for use frequency and duration (where the sample was split at the mean values for *UFyearcount* and *UDyearcount*), dissatisfaction with the window view (*viewdissat*) and having a mostly/completely natural window view (*natbuiltbi*). Initially all of the control variables for socio-demographic, socio-economic, work-related and alternative greenspace exposure factors were included. Those that were found to be clearly unrelated to sickness absence were removed. The resultant model explains 9.7-16.3% of the variance in sickness absence, and is shown in Appendix H.7.1. Unexpectedly, those who use the workplace open space on a greater number of occasions than average were more than twice as likely as others to report sickness absence levels above the UK average ($Exp(B)=2.218$, $p<0.05$). This finding does not appear to be related to smoking behaviour; this relationship remains when an additional variable is included for use of the open space for smoking. None of the other open space variables were significant predictors of sickness absence.

When the view variables *viewdissat* and *natbuiltbi* were replaced with dummy variables indicating the presence or absence of each of the objective view feature types the model explains a greater proportion of the variance in the sickness absence variable (14.9-24.2%), however none of the view feature types are significantly related to above average sickness absence. The apparent relationship between use frequency and sickness absence also disappears (see Appendix H.7.2 for model coefficients).

It appears overall that, in the population studied, absence rates are generally low and exposure to the open space at the study sites has no clear effect on sickness absence. It is possible that, in the difficult economic climate in which the study took place, sickness absence has limited value as an indicator of employee health. In a period of recession where many organisations have had to resort to redundancies, there is perhaps an added

pressure on employees to attend in circumstances where they might have otherwise been absent (known as 'presenteeism').

7.9 Conclusions

The statistical analyses reported here allow a number of conclusions to be drawn with regards to the potential cumulative effects of exposure to greenspace at peri-urban knowledge sector business sites on employees. These are summarised below with reference to the research questions set out section 7.1.

Are wellbeing levels, job satisfaction and sickness absence related to: a) window views of nature, and b) use of greenspace at the workplace?

Both use of workplace greenspace and views of greenspace were significantly related to employees' self-reported wellbeing levels, as measured using SWEMWBS. The association between use and wellbeing depended on how use levels were measured; whilst the weekly total duration of use was found to be a significant predictor of wellbeing, the frequency of use was not. Those who were more satisfied with the quality of their workplace window view reported higher wellbeing levels. There was no relationship found between the measure of view naturalness and wellbeing, however further analysis looking at what respondents could see in their window view demonstrated that this was down to the inappropriateness of the measure used, rather than the absence of an effect from viewing nature. The concept of 'naturalness' in relation to science park open spaces is explored further in chapter 8.

There was less evidence of cumulative impacts of workplace greenspace exposure on job satisfaction and sickness absence. As with the wellbeing outcome, job satisfaction was significantly and positively associated with total use duration over the course of a week, however there was less evidence of relationships with view variables. Only bushes/flowering plants in view were found to be associated with ratings of job satisfaction. None of the workplace greenspace exposure variables were reliably associated with the number of sickness absence days employees' reported for the six month period leading up to the survey.

Which is more strongly related to wellbeing outcomes – viewing or using workplace greenspace?

Regressions on the SWEMWBS outcome indicated that viewing greenspace has a greater effect on wellbeing than time spent in the open space. View satisfaction showed

a stronger relationship to wellbeing than use duration, as did several of the vegetation types seen in window views. This has significant implications for the design of both the landscape and buildings on such business sites, and suggests that priority should be placed on providing visually appealing structural planting that can be seen from different viewpoints inside the buildings.

Do certain view features promote wellbeing benefits and others limit them?

The results of the SWEMWBS modelling suggest that what can be seen in the window view from an employee's desk contributes significantly to their wellbeing levels. Overall, several vegetation types (trees/woodland, lawn/mown grass, and bushes/flowering plants) were found to be positively related to wellbeing. The most important features to promote in window views from the workplace appear to be trees and lawn. In addition to contributing towards employees' satisfaction with their view, there is evidence that viewing these features has a positive effect on wellbeing regardless of employees' subjective evaluations of their view quality.

Whilst viewing these natural features appeared to promote wellbeing, there was no evidence that viewing any of the built features has a negative impact. This points to a vast potential for promoting wellbeing through greening of the built environment.

What conclusions can be drawn about the mechanisms behind relationships between workplace greenspace exposure and wellbeing outcomes?

In terms of exposure to workplace greenspace through views from inside buildings, the research showed that the association between seeing trees, grass and bushes/flowering plants in the window view and wellbeing was not accounted for by satisfaction with the quality of the view. We may speculate that these relationships between objective view characteristics and wellbeing operate through less conscious mechanisms, i.e. effects on attention and/or psycho-physiological stress, however empirical testing of this hypothesis was outwith the scope of the study.

With regards to the association between use of the open space and wellbeing, it is not possible to conclude whether this relationship is a causal one due to the correlational nature of this study. However a causal effect is plausible given the extent of the experimental evidence on the emotional and psychological benefits of nature experience in the literature. The moderation analysis presented in section 7.5 indicates that if spending time in the workplace open space does indeed promote wellbeing, there is no

evidence to suggest that social interaction is the mechanism behind this effect. In fact, spending time in the open space with others appears to limit the extent to which employees' benefit from greater use of the space.

Do all employees benefit from exposure to greenspace at Science Park workplaces?

In this study there was no clear evidence of differential benefits between the sexes, or between those who are having more or less difficulty coping on their household's income. Neither did job-related factors like working hours, how mentally demanding respondents reported their jobs to be, or the length of time working on the site appear to influence the relationships between workplace greenspace exposure and employee wellbeing.

There were, however, clear interaction effects suggesting differences between those in environmental work and others in the wellbeing effects of exposure to these open spaces. Those working in environmental sector organisations showed no evidence of benefiting from use of the open space, nor from views of lawn or bushes and flowering plants. The exception to this is the role of trees in the window view; both environment sector workers and others appear to benefit similarly from seeing more trees. The findings of the qualitative study (to be discussed in the following chapter) and previous literature suggests a possible interpretation for these interaction effects relating to differences in perceptions of biodiversity. The implication is that with greater knowledge and understanding of natural ecosystems, a higher quality of environment (in terms of ecological integrity) may be required to promote employee wellbeing in environmental organisations. It also highlights the significance of trees in creating a restorative workplace setting for all sectors within the knowledge economy.

The moderation analysis also found that those who rate their job as being more stressful appear to benefit more than others from window views of lawns and bushes. This finding suggests that needs for stress relief may be more important in determining the benefits of exposure to workplace greenspace than the need for attention restoration in this context.

Overall the results of these moderation analyses raise important questions about what makes an environment 'restorative enough' to promote wellbeing, and for whom. This theme is explored further the following chapter presenting analysis of the qualitative data from walking interviews with employees.

Chapter 8: Employee perceptions and experiences of Science Park open space as a restorative environment

8.1 Introduction

Chapter 6 has explored employees' engagement with the open space and the factors influencing this, with chapter 7 testing for evidence of cumulative wellbeing impacts arising from this engagement. The present chapter seeks to better understand how everyday experiences in workplace greenspace may, when taken cumulatively, promote employees' overall mental wellbeing.

The findings presented here relate to the fourth objective of the study - to analyse employee perceptions and experience of the open space with respect to the restorative potential of the science park sites. The results presented in the following sections draw from both the quantitative employee survey and qualitative walking interviews. The quantitative analysis explores the perceived qualities of the open space and employees' satisfaction with the extent of certain physical features present at the sites (section 8.2 and 8.3). It goes on to analyse employees' self-reported restoration outcomes in the open space (section 8.4). The qualitative analysis focuses on the affective and cognitive dimensions of users' perceptions and lived experience of the open space on and around the sites. This discussion considers workers' beliefs about the influence of the workplace setting on quality of life (section 8.5) and the psychological benefits experienced in the workplace greenspace (section 8.6). Sections 8.7 and 8.8 go on to explore how spatial and environmental characteristics of the open space relate to these reported wellbeing benefits.

8.2 Perceived qualities of the science park open space

Survey respondents reported perceived qualities of the open space within their site using an adjective checklist. A total of 348 responded to this questionnaire item, reporting 6.9 attributes on average. The responses are summarised in fig. 8.1 and table 8.1.

Figure 8.1 and table 8.1 show that perceptions of the open space on the case study sites were generally positive. Several qualities that may indicate restorative potential were commonly attributed to the science park sites - 'green', 'attractive', 'quiet', 'natural' and

Figure 8.1: Perceived qualities of science park open space, sized by frequency of selection (illustrative only, not to scale).

'relaxing' all featured amongst the 10 most commonly reported attributes, with others such as 'calming', 'safe' and 'tranquil' each selected by more than one third of respondents. All of the sites were described by the majority of respondents as being green and well-maintained. There were significant between-site differences in the percentage of respondents describing their site as: accessible, attractive, inspiring, relaxing, natural, interesting, and well-maintained. PSP was the site most commonly perceived as being well-maintained, attractive, relaxing, and interesting. The site most frequently described as inspiring was SUIP, closely followed by PSP. HWURP was the least commonly described as attractive or natural, but its respondents were the most likely to describe the open space as accessible. RBC was described by the smallest proportion of its respondents as well-maintained, relaxing, and inspiring. It was, however, the site most commonly described as natural. WSSP was the least likely to be described as either accessible or interesting.

Table 8.1: Summary of adjective checklist responses

Descriptor adjective	% of respondents selecting adjective						
	All sites n=348	HWURP n=128	PSP n=70	RBC n=23	SUIP n=87	WSSP n=40	Chi-square (df=4)
Green	70.7	69.5	75.7	78.3	66.7	70.0	n/s
Well-maintained	70.4	65.6	82.9	52.2	72.4	70.0	10.453*
Attractive	50.3	37.5	71.4	43.5	58.6	40.0	25.424**
Quiet	46.3	44.5	50.0	56.5	47.1	37.5	n/s
Accessible	44.8	59.4	41.4	26.1	46.0	12.5	31.494**
Natural	44.8	35.9	48.6	60.9	54.0	37.5	10.723*
Spacious	43.1	42.2	48.6	56.5	42.5	30.0	n/s
Relaxing	42.5	40.6	57.1	21.7	42.5	35.0	11.301*
Tidy	42.0	37.5	42.9	34.8	48.3	45.0	n/s
Open	41.7	39.1	34.3	47.8	54.0	32.5	n/s
Calming	36.5	35.2	50.0	34.8	34.5	22.5	n/s
Safe	35.6	37.5	37.1	43.5	39.1	15.0	n/s
Tranquil	33.9	33.6	40.0	39.1	31.0	27.5	n/s
Interesting	21.6	23.4	32.9	13.0	17.2	10.0	10.659*
Varied	19.0	24.2	24.3	8.7	11.5	15.0	n/s
Inspiring	8.0	3.1	14.3	0.0	14.9	2.5	17.141**
Boring	7.5	8.6	2.9	13.0	10.3	2.5	n/s
Distinctive	6.0	3.1	10.0	0.0	10.3	2.5	n/s
Commonplace	4.9	5.5	4.3	4.3	4.6	5.0	n/s
Enclosed	4.3	7.0	5.7	4.3	0.0	2.5	n/s
Uniform	4.0	3.9	1.4	4.3	6.9	2.5	n/s
Busy	2.6	1.6	1.4	0.0	5.7	2.5	n/s
Unattractive	2.3	3.1	2.9	4.3	0.0	2.5	n/s
Unnatural	2.0	3.1	0.0	4.3	2.3	0.0	n/s
Lively	1.7	1.6	1.4	0.0	3.4	0.0	n/s
Poorly-maintained	1.1	1.6	0.0	0.0	1.1	2.5	n/s
Exciting	0.9	0.0	2.9	0.0	1.1	0.0	n/s
Unsafe	0.6	0.8	0.0	0.0	1.1	0.0	n/s
Grey	0.6	0.0	0.0	4.3	1.1	0.0	n/s
Untidy	0.6	0.0	0.0	0.0	2.3	0.0	n/s
Inaccessible	0.6	0.8	0.0	0.0	1.1	0.0	n/s
Depressing	0.6	1.6	0.0	0.0	0.0	0.0	n/s
Cramped	0.3	0.8	0.0	0.0	0.0	0.0	n/s
Stressful	0.0	0.0	0.0	0.0	0.0	0.0	-

HWURP = Heriot-Watt University Research Park; PSP = Pentlands Science Park; RBC = Roslin BioCentre; SUIP = Stirling University Innovation Park; WSSP= West of Scotland Science Park.

8.3 Satisfaction with open space features

Survey respondents were also asked to indicate whether they would like to see more of, less of, or no change to a range of open space features on their site. Figure 8.2 shows that the majority of respondents were satisfied with the status quo for most of the open space features. The exception was seating; overall 72% of respondents reported a desire to see more seating facilities at their site. A significant minority wished to see more bushes and flowering plants (43%), water features (39%), sculptures or other cultural artefacts (30%), meadow/rough grass (28%), and trees (26%). Car parking/roads and lawn and were the only features that a greater number of respondents wished to see less of than wished to see more. Fourteen percent of respondents expressed a desire for less

parking/roads, with 13% desiring less lawn/mown grass. These findings are broadly in line with Kaplan's (2007) findings on the setting changes desired by employees in peri-urban workplaces in the USA. The changes receiving the greatest support in that study were the addition of more flowers and trees, and again more respondents favoured less rather than more mown lawn areas.

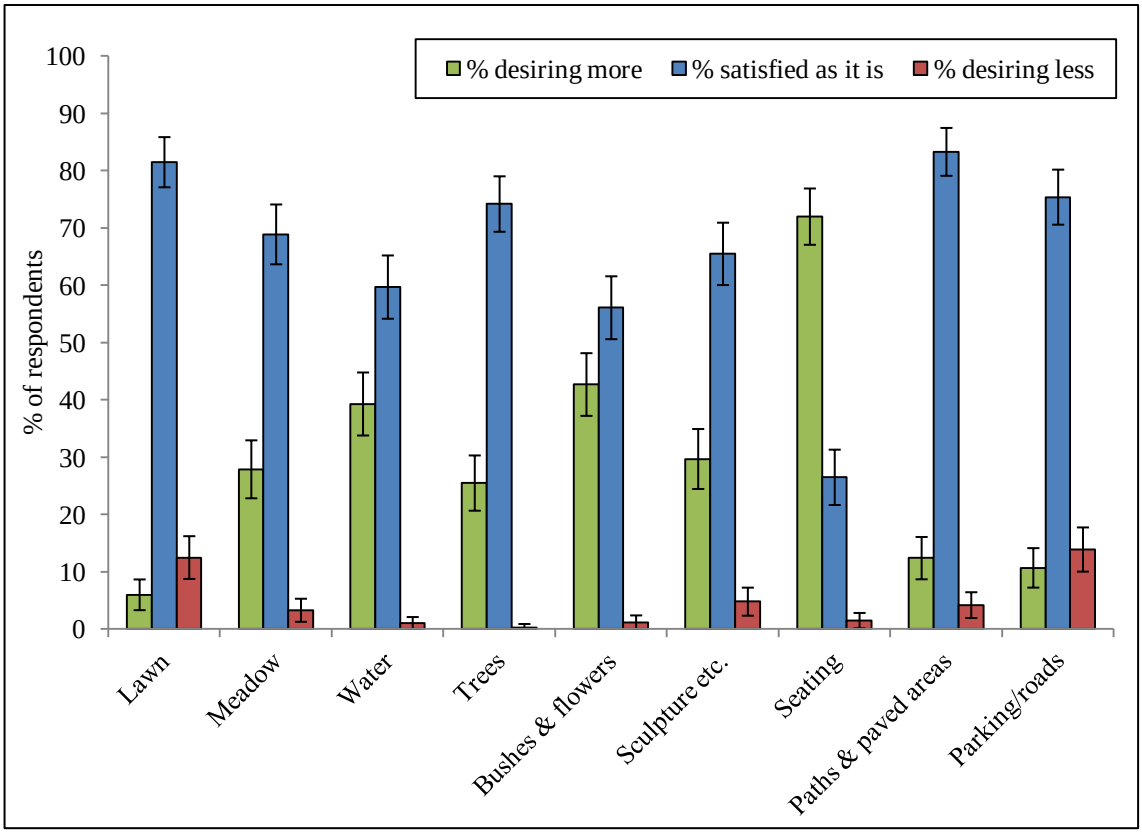

Figure 8.2: Desired changes to open space features. Bars show 95% CI.

Although the majority of respondents expressed a desire for more seating, interviewees at several sites reported that some existing seating areas were underutilised (see 6.6.4). It may be that during good weather the demand for seating during peak use at lunchtime exceeds the supply of seating *in the areas people wish to use*. Incorporating more seating (perhaps including features that can serve as informal seating e.g. low walls) within the preferred areas for sitting outdoors (see section 8.7) could help to alleviate this problem. There are also indications that a greater variety of green and blue features would be welcomed by employees. Greater incorporation of water and more varied vegetation, including more shrubs and flowering plants and unmown meadow areas, could perhaps further improve many respondents' aesthetic evaluations of the sites.

8.4 Perceived restoration outcomes in Science Park open space

Participants' self reported experience of restoration on site was measured using the six item Restoration Outcomes Scale (ROS) (Korpela et al. 2008). This section presents the results of the analysis of ROS scores. The dimensionality and reliability of the ROS were tested prior to further analysis. Principal Components Analysis confirmed that the scale items measured a single dimension and were therefore appropriate to combine into a single scale. The single factor of eigenvalue >1 explained 72.9% of the variance in item responses. Reliability analysis indicated a high level of internal consistency (Cronbach's α=0.924). Values higher than around 0.7 are considered to indicate a reliable scale, in which there is a high level of correlation between individual items (Field 2009, Brace et al. 2009). Following Korpela et al. (2008), a summary ROS score was calculated for each respondent using the mean of the six scale items. Scores above the scale mid-point of 4.0 are indicative of restoration.

8.4.1 Science park ROS scores

Across the study sites, the mean ROS score was 4.96. The mean ROS scores for each of the study sites are compared in table 8.2 below and figure 8.2 overleaf. The mean scores ranged from 4.82 at RBC to 5.10 at PSP, indicating that each of the science park sites do offer potential for psychological restoration. A one-way ANOVA indicated no effect of site on ROS scores ($F_{(4,341)}$=0.613, p>0.05).

Korpela et al. (2010) provide benchmark ROS scores for reported favourite places categorised by environment type, to which these values can be compared. In that study, the mean ROS score for extensively managed nature areas (e.g. urban woodlands, semi-natural greenspaces, fields and meadows) was 5.11, and for built greenspaces (e.g. urban parks and amenity greenspace) was 4.84, as compared to 4.54 for favourite indoor places and outdoor urban areas (e.g. city streets). The mean ROS scores for the science park sites in the present study are therefore in line with those reported by Korpela et al. (2010) for *favourite* green environments.

Table 8.2: Study site mean ROS scores (± SE mean)

All sites (n=346)	HWURP (n=127)	PSP (n=70)	RBC (n=23)	SUIP (n=87)	WSSP (n=39)
4.96 (± 0.05)	4.92 (± 0.07)	5.10 (± 0.11)	4.82 (± 0.17)	4.95 (± 0.11)	4.94 (± 0.18)

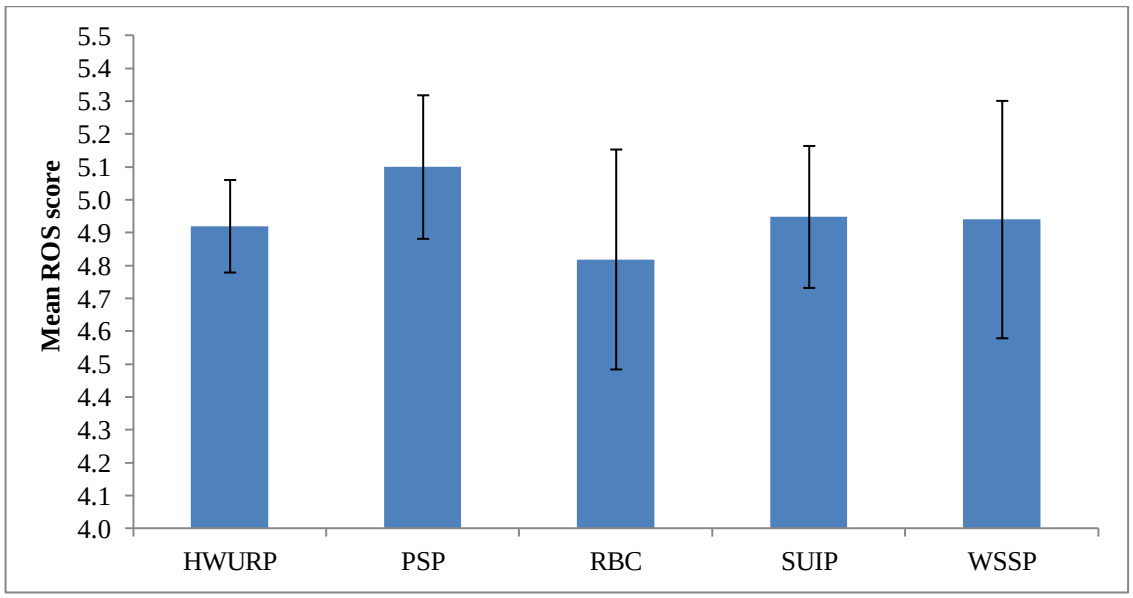

Figure 8.2: Mean ROS score (± 2xSE) by study site. HWURP = Heriot-Watt University Research Park; PSP = Pentlands Science Park; RBC = Roslin BioCentre; SUIP = Stirling University Innovation Park; WSSP= West of Scotland Science Park.

8.4.2 Predictors of ROS score

Multiple regression analysis was used to explore associations between ROS scores and other factors that could potentially influence the strength of the restorative effect experienced by individual employees. Given the moderating effect of environmental work on the association between greenspace exposure and employee wellbeing (see chapter 7), it was of particular interest to examine whether the restoration outcomes reported by environmental sector workers would differ from the rest of the sample.

The resultant model (shown in table 8.2) adequately predicted ROS score (ANOVA: $F=4.407$, $p=0.00$), explaining 15.4% of the variance in ROS. The usual assumptions of linear regression were met. Against expectations, there was no relationship between working in an environmental sector organisation and ROS score. The environmental workers, despite showing less evidence of cumulative wellbeing benefits from use and views of the open space, did not report weaker restorative experiences there.

Other factors did, however, significantly predict ROS score. Those who reported mainly using the space with others reported significantly lower restoration ($p<0.01$). This is in line with the previous research suggesting that when safety is not an issue, solitary use of greenspace is more conducive to restoration (Staats and Hartig 2004, Korpela et al. 2008, Grahn and Stigsdotter 2010, Nordh et al. 2011).

Table 8.2: ROS regression model summary. Significant associations shown in bold.

Factor	ß	p
Female	0.104	0.067
Environmental sector	0.064	0.313
Outdoor activities frequency	**0.241**	**0.000**
Work mental demands	0.001	0.994
Work stress	0.120	0.077
Income coping difficulty	0.025	0.646
Use duration (summer week)	0.010	0.878
Use frequency (summer week)	0.112	0.074
Social use	**-0.210**	**0.000**
Age	0.054	0.405
Length of time working on site	-0.092	0.153
No garden access	**-0.115**	**0.043**
HWURP (reference)	-	-
PSP	0.035	0.592
RBC	0.022	0.704
SUIP	0.039	0.513
WSSP	-0.079	0.182
Model fit		*Adj. R^2=0.154*

There was a strong positive relationship between ROS score and the frequency of participating in outdoor activities during leisure time ($p<0.01$). This is consistent with previous work by Korpela et al. (2008) using the ROS, which found both nature-based hobbies and nature-orientedness to be predictors of restoration outcomes in favourite greenspaces. Although we might expect environmental sector workers to be particularly likely to have a strong connection to nature, it is likely that the nature connectedness construct (not measured explicitly in this study) is more strongly represented by the frequency of outdoor activities variable.

There is also further evidence that greater exposure to nature across life domains is positively associated with restoration outcomes in workplace greenspace. Those who did not have access to a garden at home reported weaker restoration than those with either a private or shared garden at home ($p<0.05$). This could be a result of self-selection, with those who are less restored by greenspace choosing homes without a garden, perhaps in denser, more urban areas if they are more urban-oriented. It could alternatively be an indication that more frequent exposure to restorative green environments positively reinforces restorative responses to nature. The marginally significant ($p<0.1$) relationship between frequency of use of the workplace open space and ROS score further supports the latter explanation. This interpretation - that greater exposure to greenspace across life domains promotes restoration in workplace greenspace - goes counter to initial expectations that those with fewer opportunities for

restorative nature experiences outside of the work environment would be in greater need of restoration and would therefore benefit more from workplace greenspace.

The model did, however, hint at a relationship between restoration needs and restoration outcomes; there was a marginally significant ($p<0.1$) positive association between job stress and ROS score. This is consistent with previous research (e.g. Hansmann et al. 2007, Morita et al. 2007, Korpela et al. 2008). There was no relationship between ROS score and workplace mental demands, or income coping, contrary to the predictions of ART. This is at odds with the previous finding that those in more mentally demanding roles are more likely to cite attention restoration outcomes as a motivation for using the open space (section 6.5.3).

There were no statistically significant effects of site or demographic characteristics on ROS score. There was, however, a marginal gender effect, suggesting that women's ROS scores were somewhat higher than men's. Although some previous studies have found gender effects in restoration outcomes, these have not been consistent in direction (see section 2.5.2).

8.5 Workplace setting and quality of life

As well as holding strongly positive perceptions of the open space and setting of their workplace, most survey respondents (75.0%) agreed that the setting made a positive contribution towards their quality of life. Likewise, 79.3% reported that the outdoor environment of their workplace had many advantages compared to previous workplaces. The qualitative study highlighted the role that such comparisons between the science park setting and other likely locations for their industry sector played in framing participants' evaluations of the outdoor environment and its impact on quality of life.

8.5.1 Science parks - good for a workplace

A strong theme identified in the qualitative data was the feeling that the science park setting was 'good for a workplace'. Perceptions of the site were often strongly influenced by participants' generally low expectations for the environmental quality of business sites, and the contrasts between their current and previous workplaces or locations of other organisations in their industry sector. In this sense, there was a common feeling that science parks offered a higher quality environment than the alternative city centre, business park, or industrial estate settings.

> *"As a place of work it's probably about as nice as you're going to get, this close to a city".* (Interview participant, HWURP)

In relation to urban workplaces the contrasts in terms of traffic levels, noise, buildings, people and consumerism were valued by a number of participants, although some expressed desires to have more convenient access to shops, facilities like gyms and swimming pools, or bars for socialising after work. Several participants discussed how in a city centre office they would be more likely go outdoors during breaks for the purposes of buying lunch, visiting a cafe or shopping, rather than the healthier activities (e.g. walking or running) that they performed outdoors at their science park workplace.

> *"I think if I was in the city centre, as I was today, the focus would be on shopping. It wouldn't just be on going out, having a chat about things and just walking, for the pleasure, for the exercise. It would be a different thing. There'd be some other priority in there."* (Interview participant, WSSP)

Several participants described walking in city streets or shopping malls as an undesirable way to spend breaks, and suggested that decisions to go for a walk would depend on whether there was a park or other greenspace nearby that would allow escape from traffic, buildings and people.

Science parks were seen as particularly advantageous over more industrial settings, which for many of those whose work was largely laboratory based was seen as the most likely alternative setting for their organisation. Industrial settings had exclusively negative connotations for the participants mentioning them, with several explicitly associating these workplaces with negative impacts to quality of life:

> *"I've worked in a lot of industrial places before, industrial places like paper mills and things, you know that really feel like they sook the energy out of you. You don't feel like that here."* (Interview participant, RBC)

> *"I went to see a company in another place out in Dumbarton, it was an industrial estate and I thought 'I'd kill myself if I had to work here' - it was horrible."* (Interview participant, RBC)

Generalist business parks were often seen as only marginally better than industrial estates, with participants often using words like 'sterile', 'monotonous', and 'bland' when discussing them.

8.6 Wellbeing benefits experienced outdoors around science park workplaces

8.6.1 Being away from work

Interview participants tended to discuss the benefits of using the greenspace in terms of the value of achieving a psychological separation from work. Outdoor breaks were seen as offering greater opportunity for temporarily distancing oneself from work hassles than breaks taken indoors:

> *"It just kind of gives you an actual break. Cos I think even if you're not sitting at your desk, if you're stuck inside you do feel less like you've had a break and you've been able to switch off your brain for a minute and just relax."* (Interview participant, WSSP)

Many described this psychological distance simply in terms of forgetting about or switching off from work. Others described a conscious separation that suggested an element of breaking their identification with their work:

> *"I think it does help me to think, or realise, that I'm not at work at this point, that I'm separate from it. Otherwise I would probably be totally depressed."* (Interview participant, WSSP)

Whichever way participants described the psychological distance achieved during outdoor breaks, this was universally something which was highly valued, and which was seen as opening up the opportunity to think about different things, or just to daydream and think about nothing in particular. This psychological distancing effect is encompassed in ART's 'being away' construct. Several participants associated 'clearing the head' - analogous to attention restoration - with this feeling of being away from work. However, this feeling of being away was also clearly associated in participants' minds with stress relief and relaxation; it was described as allowing "time to unwind", "space in my head to relax", "a breather", or the opportunity to "decompress", to give a few examples. There was little evidence that participants made distinctions between cognitive, emotional or psycho-physiological benefits. For example, one participant at PSP stated:

> *"It always makes me feel better. Because it's more relaxing.... Sometimes my head just gets too full and needs to come out and get emptied again."* (Interview participant, PSP)

This highlights the difficulties in applying theories of restorative environments to a qualitative analysis of greenspace users' experience, given the interrelations between

stress relief and attention restoration. It was not only difficult to differentiate between the effects, but also the *processes* of attention restoration and stress recovery. ART emphasises cognitive processes, whereas SRT emphasises immediate automatic responses independent of thought. However it was clear that there was a strong cognitive component to the stress recovery described by participants:

> *"Well when you're at any kind of work environment things will wind you up and they do not matter in the slightest if you take a step back. And that's what going outside does – you just get outside and you go 'Ahhh, there's a world out there!' and it's still going and all the kind of crisis and catastrophes which were magnified in the lab, actually they don't matter. And that's what it does. Yeah it's very kind of cathartic and calming."* (Interview participant, HWURP)

The quote above highlights the importance of participants' thoughts and the meanings associated with the outdoor experience in influencing restoration. Although it could be argued that these thoughts are preceded by automatic, unconscious stress reduction, it seems likely that individuals' meanings do play a part in the restoration process. This is an aspect which both SRT and ART largely fail to address. Certainly in the context of the workplace there was an impression from some of the participants that meanings relating to the authenticity of their experience of being outdoors versus the experience of work played a part in the wellbeing benefits gained:

> *"I don't know, it's just it's more real than this artificial world sitting in front of a computer all day."* (Interview participant, RBC)

Both the meanings of the outdoor experience and the indoor experiences that these provide a contrast to may therefore be of importance in determining the extent to which individuals experience restoration in open space.

8.6.2 Reflection and innovation

As well as the effect of being able to switch off and forget about work, participants also described how outdoor breaks allowed the opportunity for reflection on their work. This is in line with ART's argument that the soft fascination of green environments promotes reflection as well as recovery of the ability to direct attention. Additionally, in the workplace context it appears that the perspective gained through being away - the psychological distance from work experienced in the open space - can lead to more comfortable, perhaps less emotionally loaded, reflection on work issues.

> *"I can completely switch off from it if I'm not doing anything particularly important that day, and I can just be thinking about personal things. And if I do have something coming up like a meeting or whatever and I do need to think about it I can have a little think about it in my mind, and yeah mull it over but without getting all worried about it."* (Interview participant, RBC)

This benefit was not only experienced by participants when alone but also when walking with colleagues. One participant at SUIP noted: "If there's work stuff to be discussed you can cover some work topics, but it allows you to do it in a more, I guess, relaxed and outdoor setting."

Participants reported that this more serene reflective process can aid problem solving:

> *"At times I'll come out here and I'll be thinking about something I need to do at work and it'll help me kind of understand what I need to do and how best to do it. So it helps me think like that."* (Interview participant, WSSP)

> *"...occasionally we will go out deliberately to discuss something while we're walking. I suppose you could call it brainstorming, though I hate that phrase"* (Interview participant, SUIP)

Some participants explicitly linked this reflection and problem solving to innovation and creativity:

> *"... your mind is strangely uncluttered by other things. Sometimes a change of scene can encourage innovation, just like sleeping on a problem"* (Interview participant, SUIP)

Although those who mentioned this effect did not always directly attribute it to the green environment they did tend to relate it to restoration outcomes - either, as above, linking it to an "uncluttered" state of mind, or else feeling calm and unperturbed. Another participant, the director of a small start-up company, stated:

> *"It just makes me feel a lot more calm and it's good for ideas. My business is based on ideas so it's a nice, calming sort of influence for me."* (Interview participant, RBC)

Positive affect has been shown to enhance creativity and innovation (Baas et al. 2008). Although this has been proposed as a potential outcome of restoration in green environments, this 'nature/creativity hypothesis' (Ulrich 1993) has not been empirically tested and would benefit from further research. Further evidence relating workplace greenspace with creativity through processes of restoration could lend further support to

the business case for investment in the outdoor environment of sites like science parks where innovation can be critical to the success of occupying organisations.

8.6.3 The embodied experience of green exercise

A strong theme emerging from the qualitative data concerned the role that participants perceived the embodied dimensions of green exercise to have in the wellbeing benefits derived from outdoor breaks. The concept of embodiment refers to the 'bodily aspects of subjectivity' (Audi 1999); it is 'a process of experiencing, making sense, knowing through practise as a sensual human subject in the world' (Crouch 2000:68). The psychological effects of being in a green environment were strongly associated with the sensations that users of the open space experienced. These included the bodily sensation of movement or 'stretching the legs' after hours of sedentary work, the feeling of breathing in clean and fresh air, the relief of eyestrain caused by long periods staring at a computer screen, or the sensation of sunlight or a breeze on the skin. All of these aspects were seen to contribute towards the perceived wellbeing benefits of being in the open space, which for these participants was largely time spent on the move. Probing about the distinction between these embodied effects of outdoor activity and the effects of the perception of the green environment itself revealed that participants often conflated the two - the embodied effects were not necessarily seen as being independent of the physical environment itself. In fact, several participants at first tended to describe the wellbeing benefits they experienced from this green exercise using the common parlance of 'stretching your legs' and 'getting fresh air' but on probing strongly emphasised the green environment itself, highlighting the synergy between the embodied and restorative aspects of active engagement with greenspace.

> Participant: *"I would say it definitely helps when you are just stretching your legs. It does help you kind of be more content. Or it certainly does for me."*
>
> Interviewer: *"The activity itself or the environment?"*
>
> Participant: *"Well it would be the environment. The activity's one thing but I think, walking through here it certainly does help because there's more greenery. And to me that would be more important than walking through a row of houses or buildings, you see. So, having the natural greenery, landscape of it all does help to calm you down as well as knowing that the exercise is good for you and the fresh air and stuff, so yeah, it certainly does help."*

These green environments accessed from the workplace were therefore experienced holistically as healthy environments. They were commonly seen as spaces for active recreation, for self-regulation, and places to experience the benefits of 'being outdoors' that more built up outdoor environments may fail to offer, whether due to air pollution, stressors like traffic, or being surrounded by buildings. This holistic meaning of greenspace as a healthy environment demands recognition of the subject as an active perceiver rather than a disembodied observer of environmental stimuli, highlighting the relevance of the ecological approach to perception supported by proponents such as Heft (2010), as opposed to the image-based approach commonly adopted in studies of restorative environments. As Crouch (2000:68) argues:

> *"It is evident that the world is not only 'out there' at a distance but surrounds the individual. It is touched and smelt and so on with all the senses working together. It is grasped multi-sensually. Moreover, stopping and gazing at a 'view' is only a fragment of the way the material world is 'engaged' in practise."*

The embodied dimensions of the experience may contribute towards wellbeing benefits not only through positive affect associated with endorphins from exercise and relief from the physiological conditions of sedentary computer-based work, but also by promoting states of mindfulness. Mindfulness - defined as 'the state of being attentive to and aware of what is taking place in the present' (Brown and Ryan 2003:822) - has been linked to various wellbeing outcomes including stress reduction. Mindfulness-based meditation training interventions have received increasing research attention in recent years. The mindfulness literature emphasises awareness and attention to what is happening internally (bodily sensations, thoughts and feelings) and externally in the surrounding environment as part of being in the present moment (Brown and Ryan 2003, Shapiro et al. 2006). One participant described an effect resembling mindfulness in relation to her embodied experience in the open space:

> *"I feel more relaxed afterwards, and it makes you more aware of your body because you're trying to breathe in fresh air and you're moving and you're walking so you're actually bringing your mind away from your work and back into yourself and how you're feeling."* (Interview participant, RBC)

There are considerable parallels between the concept of mindfulness and the experience of restorative environments, particularly with respect to the fascination construct of ART. Kaplan (2001) has previously drawn comparisons between meditation and restorative environments, conceptualising these as two routes to the management of

directed attention. In the case of the former, the onus is on the individual to manage their attention, whereas for the latter the environment - through fascination - achieves a similar centring of attention without effort on the part of the individual. Kaplan suggests that whilst meditation requires skill, 'given an appropriate setting, even a relatively unskilled individual could do something approximating meditation with comparatively little mental effort' (S. Kaplan 2001:500). Mindfulness may therefore be a common element of both the embodied and restorative wellbeing benefits of green exercise. Also, given that mindfulness has been related to both stress reduction and management of attentional capacities, future research on the relations between environmental experience, restoration and mindfulness may help to pave a way toward a more integrated theoretical framework of restorative environments.

8.6.4 Renewed energy

Interview participants' descriptions of how they felt on returning to work after an outdoor break varied. Some described a disappointment at having to go back indoors (particularly when sunny and warm outside), or soon feeling as if they hadn't been out at all, however most emphasised being in a more positive mood than before their break. The overriding theme across participants related to feeling refreshed and calmly energised.

> *"I think it probably makes you a lot more chilled out for the rest of the day. Yeah I feel calmer, healthier, em... cobwebs feel like they've been blown away. It's that kind of job where you are sat focusing on one task for a long time so it's definitely a good thing to just renew your energy a little bit and then you get back to it. But yeah I'd say if you've been out in the day it probably does sort you out for most of the rest of the day"* (Interview participant, HWURP)

The above quote clearly demonstrates outcomes of attention restoration and also relaxation. However, again participants often attributed these benefits to the embodied experience of getting fresh air and physical activity:

> *"Your energy levels are boosted simply by running in places like this. I know it sounds stupid that you're expending energy to gain energy but you feel much better in yourself when you get back, which gives you a boost for the afternoon"* (Interview participant, RBC)

The reference to place in the above quote does, however, indicate an awareness of a synergistic effect of the environment along with the physical activity - a view shared by some of the other runners interviewed:

> *"You know I used to think that it was strange when people said 'oh you know you come back with renewed energy' well how can you, you've just expended it all running? But you do! It's really strange. If I was to say OK then if it was the physical: let's put me on a treadmill in the gym for an hour and how would I feel? It wouldn't... it wouldn't be the same as getting out into the fresh air so it has to be the environment"* (Interview participant, SUIP)

For some the energising effect was seen to be linked to self-esteem and feeling virtuous as a result of making the effort to be active:

> *"I feel energised. I feel smug. I do, I do!"* (Interview participant, WSSP)

This self-esteem effect was mentioned both by runners and walkers - even a short gentle walk at lunchtime helped some participants to feel good about themselves, knowing that they had "at least done something". Several participants also noted a spillover effect to their energy levels and self-esteem in the evening, noting that on days where they walked at lunchtime they felt less tired and lethargic at home or felt good knowing that they had done some exercise during the day.

The energy and refreshment derived from outdoor breaks also commonly influenced participants' sense of the passage of time for the rest of the day. Many valued the fact that after this 'proper break' at lunchtime the afternoon passed more quickly since the day had been more effectively broken up by taking time to be both physically and mentally away from work.

Participants were more divided on the perceived effects of outdoor breaks on their productivity. Whilst many saw the benefits purely in terms of mood and the passage of time, some felt that this also translated to working more effectively:

> *"I actually think you feel better. I think even from the fresh air point of view, I think you work better, you feel better. And even the view from the window as I say, it all adds to a kind of good working environment. .... As I say I think it makes you... you feel better mentally, and certainly physically, and I would say you probably work better."* (Interview participant, SUIP)

These participants did not necessarily feel that time outdoors *improved* their functioning but rather it could *restore* it to a normal level, very much in line with attention restoration theory:

> *"I suppose it does have a kind of short term improvement. Maybe improvement's the wrong word... Going out probably just resets you rather*

than necessarily making me faster because what I do is... it's quite a skill intensive job and I can only do it at the speed that I can do it at cos I've done it for years. So I can't really go faster if you know what I mean. I mean coming out and having a breath of fresh air's not going to speed me up but it might, if I'm kind of flagging cos I just need to get out and get some air then that might get me back up to speed" (Interview participant, HWURP)

8.7 Restorative spaces in and around study sites

The qualitative study not only revealed the wellbeing benefits as they were experienced by users of the open space, but also the particular places that these benefits were associated with. There were some very clear patterns arising in this regard. In most cases the route participants selected for the walking interviews ventured off the main part of the science park site, usually onto either nearby landscaped campus areas (and particularly waterside environments within these) or adjacent woodlands. Although in the employee survey the open space within the science park sites were reported as being restorative (see section 8.4.1), interview participants preferred to spend time in these more peripheral areas of open space (some of which were within the site boundaries, others outwith). It was in these areas that restorative experiences were most often described. There were a number of reasons given for choosing to go further afield during outdoor breaks. One of the reasons was that the users interviewed, and particularly the regular users, reported preferring to be on the move and sought out routes that allowed a walk or run of a reasonable length. Other reasons related to the restorative qualities of these spaces, and were most clearly seen in respect to the ART constructs of being away and the fascination of nature.

8.7.1 Escape places

Achieving a physical separation from the workplace was for many an important element of gaining psychological distance or being away.

"Well I prefer the woodland as you know. I think around the buildings I'm never that relaxed. I think partly because you're never...even when you're in the landscaped areas you're actually sat right next to your work's building. Here you feel like you've.... I mean you can't see it. You've completely removed yourself away from work.... Here it's complete escape – you come here for personal time, not work's time." (Interview participant, PSP)

Not being able to see their workplace was mentioned by several of the participants. Hauru et al. (2012) found that users of urban woodland perceived the environment to be more restorative when views to nearby built up areas were obscured by vegetation. It seems that this closure of view is particularly important in the workplace context where visual separation from the buildings associated with work was highly valued - nearby areas where work is 'out of sight, out of mind' may therefore be particularly valuable in the context of open space at the workplace. Seeing other buildings not associated with the workplace itself (e.g. buildings on an adjacent university campus) did not appear to limit the wellbeing benefits for some, although others voiced preferences for not seeing any buildings at all and were drawn towards areas without any signs of development.

Other advantages of escaping from the main built up area of the science park commonly mentioned by participants was the benefit of not having to dodge traffic, not being overlooked by those working in the offices, and being alone. Both social escape and escape from the human dominated environment of buildings and cars therefore appear to be important to employees' restorative experiences off the business areas of the sites.

Woodland environments were experienced as tranquil places for privacy and solitude, which may relate to the quality of refuge in that these are places where it is easy not to be seen either by other users or by occupants of nearby buildings.

> *"The other thing I like about it is that it's quieter here than the rest of the place, so you kind of feel like you're here on your own. You sometimes see other people around but it's kind of... a woodland's easier to absorb people in and kind of lose yourself in a bit."* (Interview participant, SUIP)

Although woodlands were the preferred places for many participants regardless of professional background, the interview participants working in environmental organisations were amongst those who expressed a particularly strong identification with these environments.

8.7.2 Fascinating nature and vistas

Another clear theme relating to the areas valued for their restorative potential regards the level of interest and fascination they were seen to offer users. Descriptions of the experience in nearby woodlands indicated a high level of fascination. Participants discussed the variety of things to see, hear and smell that captured their attention there - from the birds and other wildlife, to the quality of the light filtering through the canopy at different times of the day and the smell of the woodland after the rain. The

ephemeral changes seen in woodlands throughout the seasons were highly valued. Seasonal changes in the vegetation were mentioned by several of the woodland users. Some noted preferences for a particular time of the year, but more often it was the dynamic state of the environment itself and the fact that each season was seen to offer different sensory stimuli and affordances that were most valued. Examples of these ephemeral affordances included picking berries and mushrooms, viewing the bluebell carpet of late spring, or bird spotting in winter when the barer branches made it easier to see and not just hear the birdlife. Seasonal changes in the vegetation, particularly in the colours of the leaves on the different tree species, were also an aspect of the more landscaped areas of the sites that were appreciated by participants.

Seeing, hearing and engaging with animal life during the working day was something which held meaning for many of the interviewees. Seeing wildlife and even livestock in fields (whether when outdoors on and around the sites or through windows from indoors) was a source of fascination for participants, and for some the promise of seeing wildlife if you "keep your eyes and ears open" made the environment fascinating in itself. Almost all of the interview participants mentioned different types of wildlife they had encountered around the science parks and reported feeling fortunate to have the opportunity for such experiences during their working day. A wide range of different species and taxa were reported. Most often mentioned were bird species including many types of waterfowl. Mammals such as deer, squirrels, rabbits, foxes, badgers, and stoats were also reported, as well as amphibians (frogs) and insect species (butterflies and dragonflies).

These fascinating interactions with wildlife did not always take the form of the soft fascination emphasised in ART as conducive to attention restoration and reflection. A number of participants commented on instances of aggressive competition or predation amongst the wildlife on site. For example, one participant at SUIP described an experience of witnessing a kill in action:

> *"We had a bit of a geek fest when we filmed a stoat killing, slowly strangling a rabbit - quite violent!"*

These sights - of nature as red in tooth and claw - were valued but it is not clear whether this type of hard fascination from nature is actually restorative. Even though in these circumstances the wildlife does not pose a threat to the safety of the observer, watching

such scenes may be more likely to elicit a state of physiological arousal rather than relaxation.

Opportunities to see and hear wildlife were an important element of the experience in the preferred escape places. Woodland encounters with wildlife were fleeting, but at the lochs on the Stirling University and Heriot-Watt University campuses wildlife was normally present and this appeared to be one of the key elements attracting employees to these waterside environments.

> *"I think the water's excellent because you get that water wildlife and because of the trees and the landscape around about it that attracts other stuff like squirrels and you've got rabbits, you've got stoats or weasels round about. So just the whole thing put together makes it just an excellent environment."* (Interview participant, SUIP)

Both the sight and sound of water features themselves were also mentioned in relation their fascinating qualities and restorative effects. One participant at Heriot-Watt said of the university campus loch:

> *"I love watching the water anyway. Because it moves I think, you know the ripple and the light on it. It's very calming"* (Interview participant, HWURP)

One interview at WSSP took a route close by the River Kelvin, with the interview participant noting:

> *"I think... I don't know if it plays with your mind, but it certainly kind of helps you to forget things that might have been stressing you out five minutes ago because it's like a diversion, even though you might not be listening to it directly. Just the fact there's a little rumble or a trickle of water going by, and maybe the birds and what have you, hearing them sing, it certainly does take your mind off of things at work."* (Interview participant, WSSP)

Other meaningful spaces were characterised by their affordance of prospect. Several participants led the interview to particular viewpoints which were valued not just because they offered clear views to the surrounding landscape, but also because these views were perceived to be particularly interesting or scenic.

These spots tended to be somewhat elevated viewing points offering vistas of hills and agricultural land. High levels of openness and prospect across the flatter landscaped areas was not normally characteristic of the preferred spaces, however there were some

exceptions in the case of two male participants. One participant at HWURP attempted to explain the meaning associated with the most open area of the site:

> *"If you walk just a little bit up the other side you've got almost completely open skies as well which is also quite nice. And quite often if I do need to go up to the uni for anything I will take that route because it does kind of give you that bit of open air. Quite difficult to put your finger on what it really means, or.... or what it does to you. But it is quite nice to be one person stood in a relatively open environment with no trees around you."* (Interview participant, HWURP)

For another, the chief benefit of openness was seen to be the light levels; unimpeded daylight was seen as particularly beneficial as a contrast to artificial lighting in participants' offices.

8.8 Naturalness and biodiversity in science park open space

8.8.1 Valuing naturalness

Several codes centring around the theme of naturalness were identified in the qualitative analysis. The concept of naturalness is used widely in literature on restorative environments and greenspace design, however the term is often used very loosely and is seldom defined. It is important to recognise that the quality of naturalness is not inherent to an environment, but rather is a cultural construct, and a quality that may be perceived in varying degrees by different people in the same environment (Nassauer 1995).

There are at least two dimensions to the concept of naturalness as applied by the walking interview participants. In the first case, perceptions of naturalness were often described in relation to spaces where vegetation and water dominated, as opposed to buildings and car parks. This dimension of naturalness characterises biotic and hydrological components (or green/blue features) of the landscape as diametrically opposed to built structures and other features manufactured by humans (i.e. grey features). It is in this sense that much of the research on restorative environments conceptualises the natural. This is consistent with previous research indicating that perceptions of naturalness are associated with broad environmental features such as vegetation (especially mature trees and varied vegetation), and water (Ulrich 1986, Nassauer 1995, Purcell and Lamb 1998, Hur et al. 2010).

The second dimension of participants' perceptions of naturalness is more closely related to the ecological concept of hemeroby, a measure of human impact on vegetation (Winter 2012). An entirely green/blue environment can be as much a product of human influence as city streets - manicured parks and gardens, agricultural fields, coppiced woodland, and upland heath managed by grazing and burning are all examples of green environments subject to a high degree of human impact and modification, however this influence may not always be detected by the observer as it can be subtle. Participants perceived human influence in terms of the designed nature of the open space and signs of active management. The perceived hemeroby of the open space within the site was equated with artifice by a number of participants:

> *"If you look at it it's natural, but it's kind of artificial naturalness, you know it's very... the trees are planted in lines, and the grass is mown and it's, yeah I suppose it's a bit artificial in a way"* (Interview participant, HWURP)

As previously described in section 8.7, participants tended to gravitate towards areas off the main built up area of the sites to areas they associated with escape and restoration. Not only were these places of particular restorative value more natural in the sense that green/blue elements dominated, but they also perceived as being more natural in terms of human influence. In several cases the most valued areas were picturesque designed landscapes such as the lochside areas on the campuses of the University of Stirling and Heriot-Watt University. Although these areas are designed, the design was seen as more naturalistic and subtler than the heavily structured landscape on the main area of the site, with fewer straight lines and a less manicured appearance:

> *"...it's not regimented, and there's so many different areas. And it does look as if it's all... as though it's just happened... you know without somebody having a plan about where things should go"* (Interview participant, SUIP).

Others, particularly those in environmental sector work, placed more value on 'wilder' woodland areas on the periphery of, or adjacent to, the science park. The presence of mature trees was a common feature linking these preferred escape places.

Those participants working in environmental sector organisations were particularly sensitive to human influence on the landscape, appearing to emphasise hemeroby to a greater degree than most other participants in the formation of their perceptions of naturalness and preferences towards different areas on and around the sites. These individuals were more likely than others to describe the main landscaped area of the site as "unnatural" or "urbanised". One participant at SUIP elaborated further:

> *"I suppose we're ecologists and we think well this is....from our point of view it's not the top place but actually as somewhere to work and have it it's certainly a good recreational space... It's funny this place because it's easy to look at it when you first come here and think this is a sort of - feels not quite semi-industrial but it feels very developed and maybe for someone like me and others that I work with it's very easy for us to see that as a kind of second-grade environment."*

Another participant described plantings in the open space as "monoculture" and "easy care, you know, the plants that aren't particularly interesting but they fill a space". It was also felt by some that the science park open spaces were a product of their time and that "a more modern landscape designer might have something a bit more curved, might have been a bit more natural to it."

Therefore, for environmental sector workers, softer, more varied landscape designs could potentially improve perceptions of the open space on business sites. It is possible that the particular salience of perceived human influence for environmental sector workers relates to underlying value orientations. Previous research has indicated that ecocentric values towards the natural environment (where the intrinsic value of nature is emphasised over the value of nature in meeting human needs) are associated with preferences for wilder landscapes and more negative attitudes towards development (Kaltenborn and Bjerke 2002, Park et al. 2008)

8.8.2 Management and cues to care

Considerations of the management regime in science park open space are closely linked to the theme of perceived naturalness. Participants were aware that the open space was managed; with grass-cutting the most commonly reported sign of active management. It was widely recognised that for economic reasons the planted species in the built up areas of the sites were necessarily low maintenance. Although these hardy evergreen shrubs that dominated the planted beds were not particularly highly valued, interviewees across the sites saw these as unavoidable in such developments.

On the whole participants at each of the sites thought that the open space was generally well managed. The perception that the space was well-maintained or nicely kept was often one of the first things mentioned by participants when describing their overall impressions of the site. Cues to care such as absence of litter and the maintenance of a neat and tidy aesthetic were highly valued by most participants. Those working at PSP were particularly positive about the level of care put into keeping the grounds. One

participant at PSP, director of a small high-technology start-up, highlighted that this level of care comes at a cost, but for him it is money well spent:

> *"We pay for it of course - as well as the rent for the building we have to pay for the keeping of the grounds and the security aspect - so there's an extra cost, which is quite considerable... but I think it's worth paying. And it's certainly attractive to our visitors, to our customers.... and the fact it's fully occupied says something for it."* (Interview participant, PSP)

Participants at several of the sites gave specific examples of positive management practices. These included efforts made to tackle invasive non-native species (e.g. proliferation of Azolla Fern in the loch on the Stirling University campus), caring for the wildlife (e.g. ringing of the cygnets at the loch on the Heriot-Watt University campus), and efforts to promote access (e.g. to woodland areas at PSP through maintaining trails and resurfacing paths). However, some voiced desires for more sensitive management, citing examples of areas that were considered overly manicured or that could be mown less frequently, and showing the researcher examples of shrubs that were felt to have been over-pruned. Several participants who were content with the management of their site noted that they would not like to see it more intensively managed, preferring a lighter touch approach:

> *"I mean the way the bushes are growing just now, they aren't even trimmed back. It looks a wee bit fake when they're all trimmed back if you see what I mean. I'm not saying let them grow into the building but it's nicer when they're a wee bit more natural."* (Interview participant, RBC).

> *"Yeah I don't like it if it looks... you know if it starts to look a bit too much like something out of The Sims then it's not quite right!"* (Interview participant, HWURP)

There were, however, safety aspects highlighted with regards to keeping hedges bordering access roads and car parks trimmed. One participant at HWURP noted how during summer a hedge next to parking spaces in front of his building tended to obscure his view when reversing out, and another at SUIP recalled an incident where he was knocked from his bicycle, felt to be a result of a hedge obscuring the car driver's view.

Overall, for the majority of participants, good management of the open space resource in the vicinity of the buildings meant striking a balance between naturalness and the neat and tidy aesthetic appropriate for a business environment. What was considered the correct balance did, however, vary between individuals - whilst some participants advocated leaving some areas unmown, others felt that this would look unkempt:

> *"No, I like it maintained, because I think particularly given this area, I think if it was left to be overgrown it would look unkempt - I think it would look less business-like. I think it's got to look professional - the first image when people come up to visit us... I'd rather it look like we mean business."* (Interview participant, WSSP)

This tension might be overcome by locating meadow areas in less visible areas of the site, and/or by applying what Nassauer (1995) terms 'orderly frames' to 'messy nature' - highlighting deliberate intent e.g. by leaving unmown strips bordered by mown grass, or mowing strips around buildings and leaving areas on the periphery unmown:

> *"I think there's a happy medium... I think you've got to have a balance, you've got to have some kind of maintenance and some sort of grass cutting, but if it's sensible - you know they cut it as I say 3 or 4 yards from the building wall and leave the rest and that's fine."* (Interview participant, SUIP)

Overall the findings suggest that clear signs that the environment is well cared for - 'cues to care' - are important for positive perceptions of science park open space, in line with previous research in business sites and in other urban settings (Nassauer 1995, Hands and Brown 2002). Cultural norms prescribing a neat and tidy aesthetic in designed open spaces (Nassauer 1995, Williams and Cary 2002) are perhaps at their strongest in the corporate context. However employees also value a certain degree of naturalness in the landscaped open space. Previous research has similarly found that employers value naturalness in potential business locations, preferring more naturalistic landscaping to large amounts of mown grass, as long as setting care is evident (Burton et al. 2008, Snep et al. 2009). Sensitive management should therefore seek to balance tidiness with an appropriate level of naturalism, e.g. by allowing shrubs to grow but not become overgrown (confining the most frequent trimming to hedges and bushes that could limit the visibility of road users) and considering a structured approach to leaving some areas less actively managed whilst also conveying this as an intended measure rather than simply a lack of care.

8.8.3 Perceived biodiversity

Design and management impact not only on perceptions of naturalness, but also on biodiversity. The biodiversity value of the science park sites was something that many participants had not previously given consideration to. Environmental sector participants were, however, much more likely to be engaged with this issue. Some participants reported actions taken by themselves or their colleagues to promote

biodiversity, which included putting out bird feeders, erecting bat boxes, cultivating bee gardens and trampling bracken to promote natural woodland regeneration. The environmental organisations had also affected changes by putting pressure on the site management to alter maintenance practices, commonly by requesting that certain areas near their building be left unmown. Another example given was of deadwood being left on site at the request of an environmental organisation at SUIP after a tree adjacent to their office was felled for safety reasons.

The literature reviewed previously in section 2.4.4 highlighted the potential importance of biodiversity, and perhaps more significantly, *perceived* levels of biodiversity, for restoration outcomes. The perceived level of biodiversity in urban open spaces has been found to be positively related to restorative outcomes, however individuals' perceptions of biodiversity do not always reflect objective biodiversity measures (Fuller et al. 2007, Dallimer et al. 2012). This could create potential for conflict between the ecological and health promotion functions of greenspace. In order to reconcile these objectives it will therefore be important to understand the cues that are used to form perceptions of biodiversity and how these correspond to objective ecological indicators of biodiversity.

8.8.4 Cues to biodiversity

General cues to perceptions of biodiversity

Interviewees were asked about their perceptions of the biodiversity of the science park study sites and the reasons for their judgements. The cue to biodiversity most commonly stated was the presence of (visible) wildlife, with many participants listing different species that could be seen on site as evidence of its biodiversity value. Although several held the view that the more built up areas and formal landscaping on the site (particularly the mown grass) were of less biodiversity value than more peripheral areas, the presence of wildlife (e.g. deer, various bird species) was seen by some as evidence that these spaces did hold value as habitat. Other cues used to judge biodiversity levels related to the different types of habitat available on site e.g. perception of a variety of vegetation types, structural variation in the vegetation, the presence of running water (riparian habitats) and agricultural fields on undeveloped areas of the site. These cues - the abundance and diversity of visible wildlife and presence of different types of habitat - reflect cues to perceptions of biodiversity suggested in previous research (Fuller et al. 2007, Jorgensen and Gobster 2010, Dallimer et al. 2012). Tree coverage has also been suggested as a cue to biodiversity

(Lamb and Purcell 1990, Purcell and Lamb 1998, Dallimer et al. 2012, cf. Fuller et al. 2007)), however this did not appear to be a key factor influencing employees' evaluations in the present study.

The common cues used by the science park open space users may correspond broadly to objective measures of biodiversity. Associations between the frequency of seeing wildlife has been seen to correlate strongly with actual plant and bird species richness (Nassauer 2004). However, whilst there has been great interest in the potential utility of using the diversity of species in some (more visible) taxa like birds as a surrogate for measures of species richness for other less visible taxa (such as insects groups), empirical studies have found mixed evidence of covariation in the diversity of these animal groups (Prendergast 1997, Blair 1999). Habitat diversity, on the other hand, is in itself a dimension of biodiversity. It may also be a useful surrogate for species richness as habitat heterogeneity in urban and suburban greenspaces have been found to predict overall diversity of plants, amphibians and breeding bird species (Cornelis and Hermy 2004) and open spaces with a complex vertical vegetation structure can support a greater number of bird species than those with few vegetation layers (Sandstrom et al. 2006). However other studies suggest that if high value habitat patches are small and fragmented, increased heterogeneity may actually limit biodiversity (Ewers et al. 2005). Therefore, insofar as it is possible for untrained observers to judge overall biodiversity levels, these cues have the potential to result in reasonable evaluations of greenspace biodiversity. However given the complexity of ecological systems and the large number of (interacting) factors influencing the species richness of different taxa, such simplistic heuristics are not sufficient for the accurate perception of biodiversity in all environments. Nevertheless, knowledge of the cues that people use to form perceptions of biodiversity in designed open spaces may help landscape professionals to integrate human health and ecological objectives. If ecological designs can at the same time incorporate cues that will signal to users the biodiversity value of the space, this may open up new opportunities for integrating the principles of ecological aesthetic and scenic aesthetic paradigms (e.g. Parsons and Daniel 2002, Gobster et al. 2007) in open space design.

Additional cues to biodiversity used by environmental sector workers

There was evidence that some of the environmental sector workers used additional cues not mentioned by others. In some cases this led these participants to perceive sites

considered by others to be rich in diversity as being of much lower biodiversity value. The additional cues used by environmental sector participants included references to particular plant species on the site e.g. noting the balance of native to non-native tree and shrub species, wildflower species growing in unmown areas, and the absence of "interesting" or unusual plant species in the more landscaped areas. The absence of certain animal species was also noted; one participant (an ecologist working at HWURP) mentioned the absence of particular bird species that one might expect to see in surrounding agricultural land, stating that "what you do see here you can see in any garden in a suburb of Edinburgh". The presence of deadwood in woodland at SUIP was also mentioned in relation to biodiversity value.

Professional background has previously been seen to influence perceptions of biodiversity (van den Berg et al. 1998), and ecological knowledge in particular improves the accuracy of biodiversity perceptions (Dallimer et al. 2012). This research shows that those with professional knowledge about biodiversity promotion used a more complex set of cues to biodiversity than others, which can lead to these workers perceiving these sites to be of lesser biodiversity value. If, as suggested by Fuller et al. (2007) and Dallimer et al. (2012), *perceived* biodiversity is an important predictor of restoration outcomes in greenspace this finding implies potential constraints to the restorative value of science park sites for those working in environmental management and related professions. This may help to explain the interaction effects reported in the previous chapter (section 7.6), whereby environmental sector workers did not appear to accrue cumulative benefits from use of the open space, nor from viewing features such as mown lawn or shrubs from indoors. It also implies that in terms of the role of the biodiversity of outdoor workplace environments in supporting employee wellbeing, the bar is effectively set higher for those working in the environmental sector. Science park sites aiming to create a hub of environmental sector organisations should therefore pay particular attention to promoting biodiversity in their initial design and in on-going management practices.

8.9 Conclusions

This section aims to synthesise the various findings from the quantitative and qualitative studies with respect to employees' perceptions and lived experience of the open space on the case study sites.

8.9.1 Employee perceptions of science park open space

Science park workers' perceptions of the outdoor environment of their workplace were in general very positive. Overall the sites were perceived as being green, well-maintained, and attractive by the majority of survey respondents (see section 8.2). The majority of respondents were satisfied with the extent to which different open space features were represented on their site, the exception being seating facilities – over 70% reported desires for more seating (section 8.3). Incorporating more seating facilities in the open space of science parks may therefore offer workers more opportunity for passive relaxation in the open space, however as noted previously in chapter 6 (6.6.4) the location of seating should be carefully considered otherwise it may not be well used.

The qualitative study revealed the different meanings employees associate with science park open space. It was clear that most workers' perceptions of the open space were informed by using other business settings as a frame of reference, rather than open spaces encountered in other life domains (e.g. parks or countryside nature areas visited during leisure time). In this respect, the science park setting was seen to compare very favourably to city centre business locations, generalist business parks, and to industrial parks in particular - in terms of both the quality of the environment and its impact on quality of life.

Employees reported preferences towards the more 'natural' places on and around the study sites, as opposed to the formal landscaped areas around the building. From one perspective, naturalness referred to the balance between green/blue and grey (or built) features in the environment. Another meaning of 'natural' related to the level of human influence on the landscape (analogous to the ecological concept of hemeroby). A key conclusion from the findings of the qualitative study is that there is a clear need for management practices to strike a balance between naturalness and tidiness in the main developed areas of such sites. Participants valued the quality of naturalness, but also highly valued open space when they saw it as being well cared for, and felt that this was important in maintaining a professional image. Cues to care were therefore important in creating positive perceptions of science park open space, and were not necessarily seen as being incompatible with maintaining a certain quality of naturalness in the landscaped areas of the sites.

Perceptions of biodiversity also related to the theme of naturalness and the management of the open space. Common cues used by participants in their perceptions of the

biodiversity value of the site were, firstly, the abundance and diversity of visible wildlife, and secondly, the presence of a range of different types of habitat. As discussed in section 8.8.3, perceiving such cues to biodiversity may promote restorative benefits of open space, and therefore attempts to incorporate such cues (alongside cues to care and to perceived naturalness) into open spaces may be of value in supporting both the health/wellbeing and ecological functions of open space. Cues to perceptions of biodiversity were seen to be more complex in the case of those with professional ecological knowledge. In terms of the health benefits of workplace open space, it may be particularly important for sites serving the environmental sector to prioritise management practices that promote biodiversity. The findings also suggest that environmental sector organisations seeking to support the wellbeing of their staff may see particular benefits from locating at sites with greater potential to support biodiversity and/or by engaging with site management to add both ecological and social value to their settings by both promoting biodiversity.

8.9.2 Restoration and the experience of science park open space

The findings of the quantitative study suggest that science park workers consciously experience restorative outcomes in the open space on these sites, as indicated by the analysis of the ROS scores (section 8.4). This analysis highlighted some differences between individuals in the magnitude of the restorative outcomes reported; these appear to relate to individuals' contact with nature and greenspace outside of work, as well as the social context of their use of workplace greenspace. Those who reported frequent participation in outdoor activities in green environments also reported greater restoration outcomes in the workplace open space, as did those who have a garden at home. This evidence suggests that the relationship between the restorative benefits of greenspace in the workplace and those of contact with nature in other life domains is not compensatory in nature. Rather it appears that contact with nature outside of work reinforces the benefits of spending time in greenspace at the workplace. One speculative interpretation of this finding is that, across life domains, experiencing restoration in greenspace strengthens individuals' connection to nature (see section 2.5.3), which may in turn reinforce the wellbeing benefits of further nature experiences.

Furthermore, the modelling of ROS scores indicated that those who tend to use their workplace open space in company report significantly lower restorative outcomes than those who more often spend time outdoors on their own. This finding on the restorative

effect of discrete exposures to the open space is in line with findings of previous studies (see 2.6.2), and corroborates the present study's findings relating to cumulative effects of use of the open space (reported in 7.5.2). It seems that in terms of both the discrete and cumulative wellbeing benefits of greenspace use, being alone in the environment is more conducive to restoration. This has implications for interventions such as workplace walks initiatives which aim to encourage employees to go outdoors and get more physical activity during their working day. Such interventions are useful if they can increase levels of physical activity and stimulate people to make a habit of going outdoors, and may also carry wellbeing benefits by promoting social interaction amongst colleagues. However it may be that the *restorative* benefits of greenspace are not best secured by group walks, and so those seeking specifically to manage stress and/or ameliorate mental fatigue could find a solitary walk more beneficial.

The data from the walking interviews shed further light on the nature of users' experiences in the greenspace on and around science parks. The psychological benefits participants reported experiencing related primarily to:

- the feeling of 'being away' and escaping from work;
- the opportunity for calm reflection (rather than rumination) on work problems, which may also open up possibilities for creative problem solving and innovation;
- the embodied experience of being outdoors, which included relief from the physical conditions of the workplace and the physical effects of sedentary working, which may also promote a mindful psychological state; and
- feeling refreshed and having renewed energy as a result of taking an outdoor break.

These positive experiences were most often reported in relation to areas off the main developed part of the science park or in the surrounding landscape. These areas, primarily made up of woodland and/or waterside environments were seen as more natural environments than the developed area of the site, and were highly valued by those that used them. There were several themes linking these areas that may help to explain why these were more often associated with restoration. The physical and visual separation from the workplace afforded by these escape places appears to contribute significantly to the feeling of being away or achieving psychological distance from

work. These spaces also allowed the opportunity for social escape, both from other people and from a human dominated environment, to a more tranquil environment.

These natural escape places were also valued for the interesting sights, sounds and smells they offered users. Participants described the fascination associated with seeing and hearing wildlife in these areas; this was an aspect of the open space experience which was universally valued. The fascination of viewing wildlife appeared to be of particular salience in the waterside environments where waterfowl were in permanent residence. Seeing and hearing the wide range of wildlife that participants reported coming into contact with was strongly associated both fascination and perceptions of the biodiversity value of science park open spaces, suggesting that effects of (perceived) biodiversity on restoration may be at least partially explained by the fascinating qualities of biodiverse environments. In general, across the favourite places participants were drawn to, the ephemeral qualities of these semi-natural and naturalistic environments appeared to contribute strongly to their fascination. Although emerging strongly in relation to fascination in this study, the presence of wildlife and the ephemeral qualities of natural environments are under-researched topics in the literature on restorative environments.

These findings regarding the spaces that participants associated most strongly with restoration outcomes point to the value of providing science park employees with opportunities to access semi-natural and naturalistic environments away from the main developed areas of sites. In the planning and design of science park sites, priority should be therefore be given to preserving and providing access to any remnants of semi-natural or old-growth plantation woodlands and/or riparian areas within the site, even if this means that building density in the developed area will be somewhat decreased. Designs should also aim to capitalise on any greenspace resources in the immediate area (e.g. nearby woodlands or grounds of an adjacent HEI campus), by providing direct access points to promote connectivity between the science park buildings and these resources.

Chapter 9: Conclusions

9.1 Introduction

This research has focused on science parks – a development form of particular policy relevance given the drive towards regional economic development through the incubation and growth of innovative knowledge-based businesses. The thesis has argued that the health and wellbeing of employees is an important factor in the commercial sustainability of such businesses (section 1.2). It was hypothesised that the characteristics of the science park development form – with its high proportions of open space and urban-fringe location – may confer wellbeing benefits to employees as a result of everyday exposures to greenspace at the workplace.

The overarching aim of the research was to investigate the restorative value of science park open space and the potential wellbeing benefits that exposure to greenspace in this context may offer employees. Specific objectives were formulated to contribute to fulfilling this aim:

1. To review theories and empirical evidence on the restorative benefits of greenspace, with particular focus on the workplace context.

2. To explore employee engagement with the outdoor environment at science parks and the factors influencing employees' use and views of the greenspace.

3. To test for evidence of cumulative effects of exposure to science park greenspace on employee wellbeing.

4. To analyse employees' perceptions and lived experience of the open space on and around science park sites to gain an understanding of the restorative potential of the outdoor environment at these workplaces.

5. To draw conclusions and recommendations for the planning and design of knowledge sector business sites to support employee wellbeing.

To address these objectives, a mixed method case study design was adopted. Five case study science parks located within the area designated under the Central Scotland Green Network (see section 4.3.2) were studied using a mix of quantitative and qualitative research methods. The quantitative element of the study consisted of an online survey of 366 workers distributed across these sites. This was followed by a series of sixteen semi-structured walking interviews which took place outdoors on and around the study sites.

The first four of the objectives stated above have been explicitly addressed in the preceding chapters. Chapters 2 and 3 reviewed the literature on the theory and evidence on the restorative effects of greenspace, with chapter 3 focusing specifically on the workplace context (objective 1). Chapter 6 explored science park workers' use and views of greenspace at the workplace and the factors influencing these, with a particular focus on direct use of the space (objective 2). This incorporated analysis of both survey and interview data. Chapter 7 addressed objective 3, using regression models to test for relationships between employee wellbeing and exposure to workplace greenspace. Finally, chapter 8 analysed employees' perceptions and experiences of the open space at their workplace in an effort to understand more about how the physical environment relates to wellbeing and the meanings that people attach to the open space on science parks (objective 4). Throughout the chapters, the analysis has considered the implications for planning and design (objective 5).

The purpose of this final chapter of the thesis is not to reiterate all the findings applying to each of these objectives. Rather, it aims to outline the key findings from the study as a whole, integrating results across the objectives where relevant. This integration includes a list of recommendations for the planning and design of future urban-fringe business sites. In addition, it provides a reflexive discussion of the research approach, reflecting on strengths and limitations of the study, its contribution to the field and its implications for future research.

9.2 Key conclusions of the research

9.2.1 Use and views of greenspace predict employee wellbeing

The analysis of the potential cumulative wellbeing benefits of science park greenspace (presented in chapter 7) revealed significant associations between employee wellbeing and both a) use of the open space and b) views of nature from indoors.

The total time spent outdoors around the workplace predicted survey respondents' SWEMWBS score (a measure of positive wellbeing) and job satisfaction ratings. Notably, there was no such relationship found when use was measured in terms of frequency rather than total duration of time. Previous research has found no relationship between stress and *frequency* of workplace greenspace use (Lottrup et al. 2012). These findings may indicate that to promote cumulative wellbeing benefits from use of workplace greenspace, interventions should focus on encouraging workers

to spend more time outdoors as one or two relatively prolonged visits each week may be more beneficial than very brief daily visits. As there has previously been little attention to the potential effects of use of workplace greenspace on employee health and wellbeing (see section 3.2.2), this research represents an important contribution to the field.

In terms of the impact of views of the greenspace from indoors, a number of natural view features were related to wellbeing, however there was no association between wellbeing and built view features. Those who had a greater view of trees, lawn, and bushes/flowering plants reported higher wellbeing levels. In line with previous research on urban greenspace, this suggests that structural vegetation - a smooth ground layer, a canopy layer provided by trees, and intermediate shrub and herbaceous vegetation - has is a key influence on the restorative potential of designed greenspace (Nordh et al. 2009, Nordh et al. 2011).

Views of these open space features appear to have a more pronounced impact on wellbeing than direct use of the open space (section 7.3.2). This points to the importance of integrating building design and landscape design processes from an early stage in the planning of such business sites. Maximising views to soft landscaping and the wider green setting through architectural design could promote opportunities for restoration indoors at the workplace. Architectural design should also consider how best to provide security at the ground floor level without creating significant barriers to views from indoors, as security measures such as dark tinted glazing and elevated windows impact negatively on workers' satisfaction with the indoor environment and overall wellbeing (section 6.3.1).

These findings indicating positive wellbeing effects from exposure to greenspace align with the majority of the existing literature on nature in the workplace environment (reviewed in chapter 3) and other contexts such as the residential environment and institutional settings (e.g. hospitals) (see section 2.3). However, few previous studies have addressed a) the relative impacts of different types of green/blue open space features on wellbeing benefits (and none in the workplace context), or b) the differential impacts of views and use of greenspace in a given setting. This research therefore makes an important contribution to the wider restorative environments literature, as well as adding significantly to the evidence base demonstrating the business case for investment in the environmental quality of business locations.

9.2.2 Needs for stress relief influence relationships with workplace greenspace

Work demands were found to influence both decisions to use workplace greenspace and the psychological benefits of use. Those reporting their job as highly stressful spent more time outdoors (section 6.4.2), and reported marginally stronger restoration outcomes from use of the open space (section 8.4.2). There was also evidence that the cumulative wellbeing benefits of bushes/flowering plants and lawn in window views were greater for those in high-stress roles (see section 7.6). This suggests that workplace greenspace may be a particularly valuable resource for those experiencing work-related stress.

These findings are in accordance with expectations based on stress recovery theory, and with previous research which has demonstrated that antecedent psychological states are associated with motivations to visit greenspace, as well as the strength of restoration outcomes (see discussion in 2.5.1). However, there were no such effects with respect to the *cognitive* demands of respondents' work, contrary to the predictions of attention restoration theory. Survey respondents' ratings of the mental demands of their work did not relate to their use of the open space, or to the discrete or cumulative psychological benefits of use and views. This is not to say that attention restoration was not an important dimension of the open space experience for science park workers. A greater number of survey respondents reported motivations relating to attention restoration ('clearing the head/regaining focus') than cited stress recovery ('to relax/forget about work hassles') as a motivation for use (20.6% and 14.1% respectively). Interview participants described feeling mentally refreshed and energised by outdoor breaks, and felt that clearing the mind by spending time in the greenspace was conducive to reflection and problem-solving (section 8.6).

9.2.3 Restorative benefits of workplace greenspace use depend on social context

Previous studies have suggested that spending time alone in greenspace is more conducive to effective restoration than being in company, although this relationship may be moderated by perceptions of safety (Staats and Hartig 2004, Korpela et al. 2008). The findings of the present study clearly demonstrate that both discrete restoration benefits and cumulative impacts on wellbeing are influenced by the social context of use. Those who tended to use the science park open space in the company of others reported experiencing weaker restoration outcomes (section 8.4.2), and the evidence of a moderating effect of social use on associations between use and employee

wellbeing (section 7.5.2) indicated that this group did not benefit from greater use of the greenspace to the same extent as those mainly spending time there alone. It is notable, however, that regardless of the amount of time spent outdoors in the open space, those who tended to experience it in the company of others reported high levels of positive wellbeing. It may therefore be that social use of the open space reflected higher underlying levels of social capital in the workplace, which in itself contributed positively to employee wellbeing.

There are several implications of these findings. Firstly, when individuals feel particularly in need of *restoration*, they may best address this by taking a solitary break outdoors. Secondly, the findings suggest that use of the open space may be able to compensate for low levels of social capital at work by buffering the negative effects of low social capital on wellbeing (see section 7.5.2). Social use of the open space may promote employee wellbeing if it contributes to building and reinforcing positive relationships between colleagues. There are, however, indications from the qualitative data that social use of the open space reflected pre-existing norms for social breaks (whether breaks were taken indoors or outdoors). This may explain why greater use did not appear to further promote wellbeing in those who used the open space mainly with others. On the basis of these findings we might conclude that the chief potential of workplace walks interventions is in promoting active lifestyles and encouraging interactions outwith individuals' normal social groups at work, rather than in providing opportunities for restorative experiences per se.

9.2.4 Environmental sector workers respond differently

The research highlighted a number of ways in which environmental sector workers' relationships to the open space differed from those of workers in other business sectors. Although this group tended to spend more time in the open space at their workplace (section 6.4.2), there was less evidence of cumulative impacts of use and views of the open space on their wellbeing. Moderation analysis revealed a significant interaction effect of working in an organisation with interests in environmental management on the relationship between use and wellbeing (section 7.6). Unlike workers in other sectors, there was no significant relationship between use and wellbeing for this group. Somewhat in contradiction to this finding, the analysis of discrete restoration outcomes (as measured using the ROS) indicated no significant differences between

environmental sector workers and others in restoration outcomes experienced (see section 8.4.2).

Similar interaction effects were found with respect to two of the three view variables that had predicted wellbeing in the full sample of survey respondents; the extent to which views contained lawns and bushes/flowering plants did not relate to environmental sector employees' wellbeing. However, there was no significant interaction effect found in the case of views of trees - seeing more trees was associated with greater wellbeing regardless of business sector (section 7.6).

A possible interpretation for these moderation effects relates to differences in perceptions of the ecological integrity of the open space. Environmental sector interview participants tended to perceive these sites to be lower in biodiversity value and less natural than other participants. Participants with professional ecological knowledge used much more nuanced cues to judge biodiversity levels than others, indicating that for these employees the bar is effectively set higher in terms of the level of biodiversity value needed for aesthetic appreciation of these spaces. Previous research suggests that perceptions of biodiversity are positively associated with wellbeing benefits of greenspace (Fuller et al. 2007, Dallimer et al. 2012). The mown grass and hardy shrub plantings that form a substantial proportion of the landscaping on the developed parts of the science park sites were perceived in a negative light by several of the environmental sector interview participants, however trees and woodland were strongly valued. Nordh et al. (2011) have reported that in designed urban open spaces, those with professional experience relating to parks and open space have particularly strong preferences for trees. Previous research has demonstrated the contribution of mature trees to both employers' and employees' perceptions of environmental quality at business sites (Kaplan 2007, Burton et al. 2008). These findings suggest that trees in the workplace setting are of particular importance in creating a business setting that supports the wellbeing of environmental sector workers.

The walking interviews in particular indicated that for science park open space to support the wellbeing of these workers, biodiversity promotion may be particularly important. Science parks and business clusters aiming to create specialist hubs for environmental sector activities should therefore prioritise conserving remnants of semi-natural habitats and applying sensitive management practices (e.g. maintaining wildflower meadows). Examples from the case studies also highlight the value that

science park management can deliver by engaging with environmental organisations based on site to collaboratively develop measures to promote biodiversity.

9.2.5 Greenspace off the developed area of the site offers the greatest opportunities for restoration

Survey responses indicated that employees experience the open space on the study sites as restorative environments, reporting restoration outcomes of a similar magnitude to those reported in previous research on valued green environments (section 8.4.1). The walking interviews highlighted how different areas on and around the study sites were experienced by users. The interview participants reported preferences for areas of greenspace away from the main built up area of the sites (see section 8.7). These spaces tended to be characterised by woodland and/or the presence of water bodies. They were also perceived as being more naturalistic environments than the open space areas around the buildings. These were the spaces that participants most often related to restorative experiences. These 'escape places' were seen to offer opportunities to achieve a physical and psychological distance from work, as well as escape from the traffic, buildings and social density of the built environment. They were also highly valued for the rich array of sensory stimuli and fascination they afforded. The enhanced opportunities to see wildlife, as well as the ephemeral qualities of these environments, were seen to contribute strongly towards their fascinating quality and to users' attachment to these places.

These findings point to the value of semi-natural and naturalistic designed escape places in the context of business sites in offering employees opportunities for restoration during the working day. In this respect, conserving woodland areas on development sites and promoting access to such areas, as well as to off-site woodland and riparian greenspace resources in the vicinity, could help to support outdoor use and consequently employee wellbeing.

The power of woodland and waterside environments to elicit restoration has been widely reported in the literature on restorative environments (see section 2.4). However, very few studies in the field of restorative environments have investigated how ephemeral changes (e.g. throughout the seasons, in different weather conditions and at different times of the day) influence processes of restoration (see section 2.6.4). Ephemeral qualities have likewise received little attention in the wider landscape

perception literature; this can be traced to the traditional reliance on methodologies based on static images (Brassley 1998).

Opportunities to come into contact with wildlife may also be considered as an ephemeral element of landscape experiences. Affinities towards wildlife are recognised in the biophilia hypothesis (Wilson 1984). There is prior empirical evidence suggesting that animals capture and hold our attention (i.e. are a source of fascination), and positive physiological responses to watching wildlife at ease in their surroundings have been theorised (Katcher and Wilkins 1993). However, wildlife as an element of natural landscapes has been neglected in studies of restorative environments. Again this may stem from the traditional focus on the use of static images in landscape representations. This represents a significant gap in the literature, as the present study suggests that wildlife plays a significant role in the meanings that people attach to green environments, and particularly waterside environments. The findings also suggest that visible wildlife plays a central role in cueing perceptions of biodiversity. It is therefore possible that wildlife visibility may mediate relationships between biodiversity and wellbeing observed in previous research by Fuller et al. (2007). Future research might therefore explore this potential relationship. There is a strong theoretical basis for this hypothesis. Given the fascination terrestrial wildlife was seen to elicit in the present study, and the functional-evolutionary affordances that wildlife may signal (e.g. as game to hunt, or as indicators of the presence of fish to catch or proximity to valuable vegetal food sources or freshwater sources), wildlife as part of the landscape experience has relevance to both attention restoration and stress recovery theories of restorative environments.

9.2.6 Embodied experiences play an important role in psychological benefits of workplace greenspaces

The embodied dimensions of outdoor experience were found to strongly influence both motivations for taking breaks outdoors and the wellbeing benefits attributed to such breaks. Sedentary work, extended computer-based working, and the environmental conditions of offices and laboratories (e.g. ambient temperatures, air quality and lighting) can lead to physical discomfort which may be alleviated by taking breaks outdoors. Stretching the legs, getting fresh air and experiencing daylight and sunshine featured highly in both motivations for spending time outdoors (section 6.5) and were often mentioned in relation to the psychological benefits of outdoor breaks (section

8.6.3). Other embodied aspects of the experience - relief for eyes strained from computer use, and feeling the elements against the skin - were also highlighted by interview participants as contributing to feelings of wellbeing in the greenspace.

The implications of these embodied dimensions of open space experience for *mental* wellbeing have received little attention in the literature on greenspace and health. Their salience for science park workers in the present research suggests that this topic warrants further investigation. For the walking interview participants the embodied experience of being outdoors and the restorative effects of being in nature were strongly interconnected. It may be that the significance of these embodied aspects of outdoor experience for wellbeing is particular to the workplace context, where the physical conditions experienced during long hours of desk-based working contrast strongly with the bodily sensations associated with being in greenspace. However, given the prevalence of indoor sedentary lifestyles across life domains in modern society (Hitchings 2010), it is unlikely that these aspects of experience impact on affective and cognitive states solely in the work domain.

Therefore, an important topic for future research is to improve understanding of how the wide range of embodied experiences in greenspace relate to restoration outcomes. In order to do this it will be necessary for researchers to adopt an ecological approach to perception; viewing greenspace users as active, embodied, perceivers rather than observers of landscapes as images (Gibson 1979, Heft 2010).

Qualitative research influenced by interpretative phenomenological analytical approaches might prove fruitful in this regard as these have been used to good effect to investigate embodied experience in relation to other phenomena (Smith and Osborn 2003, Standal and Engelsrud 2013) . Although commonly reported motivations for greenspace such as getting fresh air and sunlight (e.g. Irvine et al. 2013) have clear embodied dimensions, these have tended to be considered more in relation to physical health than to mental wellbeing. This research highlights that greenspace users experience psychological benefits that they strongly relate to these embodied experiences. However, the embodied experience of the environment could be argued to be inadequately represented in conceptual frameworks linking greenspace and wellbeing; it is often only recognised in relation to physical activity as a potential mechanism through which use of greenspace influences wellbeing. It is argued here that there is a potential theoretical convergence between the embodied outdoor

experience and the experience of restorative environments in that both may elicit states of mindfulness. Mindfulness - 'the state of being attentive to and aware of what is taking place in the present' - is a relatively new concept in academic enquiry, but its roots can be clearly traced back to Eastern philosophy (Brown and Ryan 2003:822). Mindful states of consciousness have been linked to both stress reduction and attentional functioning (Brown and Ryan 2003, Zylowska et al. 2007). Future research might investigate and theorise on how the embodied aspects of outdoor experience, along with the other sensory dimensions (visual, auditory and olfactory) considered to contribute towards the experience of restoration, can trigger states of mindfulness which may result in outcomes of stress reduction and improved attentional functioning.

9.3 Recommendations for the planning and design of knowledge-sector business sites at the urban fringe

The research showed how physical characteristics of science parks acted both to promote and to constrain use of the open space and opportunities for restoration. A number of implications for planning and design practice have been discussed in the reporting of the research findings in chapters 6, 7 and 8. This concluding section summarises these points in the form of an integrated set of recommendations for the planning and design of science parks.

Many of these recommendations will also have relevance to the planning and design of other types of urban fringe commercial development targeted at knowledge-sector industries e.g. business parks and large single-user developments. In Scotland, science parks fall within Class 4 (business) under the Town and Country Planning (Use Classes) (Scotland) Order 1997. This class comprises most office uses, research and development of products and processes, and industrial processes that can be carried out in a residential area without detriment to the amenity of the area. It is likely that many of the recommendations, presented in box 9.1 below, are also applicable to other urban fringe developments falling within this use class.

Box 9.1: Recommendations for planning and design

1. **Maximise views of nature from indoors** - Landscape and building design should be considered in relation to one another from the outset in order to maximise views of vegetation. Existing scenic landscape settings should be considered as a resource to be capitalised on in building design.

2. **Prioritise preservation and planting of trees and woodland** - Trees and woodland were highly valued by employees and associated with restoration opportunities, both in views and use of the open space. Maximising the variation of broadleaved and coniferous tree species may be beneficial for maintaining year round views of greenery whilst at the same time emphasising the ephemeral qualities of trees and woodland throughout the year.

3. **Emphasise structural diversity of vegetation around buildings** - A varied vertical structure comprising smooth ground textures (affording high legibility), intermediate layers of shrubs and flowering plants, and canopy trees may promote the restorative potential of views from indoors. Vertical and horizontal vegetation diversity, delivering a variety of habitats for wildlife, may cue perceptions of biodiversity and promote opportunities for restorative interactions with wildlife, whilst also delivering ecological benefits.

4. **Provide access to naturalistic escape places** - Semi-natural and less formally landscaped areas, visually separated from the buildings, are highly valued by staff and offer important opportunities for restorative experiences. Woodland and waterside environments are particularly favoured. Natural viewpoints providing interesting and scenic vistas to the surrounding landscape were also valued highly.

5. **Maximise connections to local paths networks** - Promote access routes to nearby recreational opportunities at any adjacent HEI campuses and in the wider setting. Access to the types of 'escape places' discussed above is particularly valuable. Since much of the use of the setting by workers is active, providing a variety of routes for walking/running can promote physical activity as well as opportunities for restoration.

6. **Plan for circular pedestrian routes** - Users preferred to walk/run around a circular route rather than to and fro on a linear route. Functional use of site open space (e.g. visiting catering facilities in another building) was also often extended when indirect detours between buildings were available. Providing a coherent network of paths and pavements providing a variety of options (including circular routes of different lengths) is therefore important to promote use of the open space.

7. **Locate building entrances to maximise access to the outdoors from individual units** - Direct exits from units can act as valuable bridges to the outdoors, and incorporating these into the design this may avert unintended uses of fire exits. The areas around secondary building exits are important for passive social use, particularly during good weather. Social use is more likely to occur here than in more visible and formal spaces around the primary building entrance.

8. **Provide seating areas at the back or side of buildings, close to secondary exits** - These areas tend to fall more within what is perceived as 'company territory'; concentrating seating in such areas may promote ownership of the space and therefore use. Seating in more 'communal' areas is less likely to be used. Picnic tables attract greater use than benches. During particularly good weather demand is likely to exceed available seating; this may be addressed by incorporating informal seating opportunities (e.g. low walls and ledges) into design.

9. **Communicate the hierarchy of space through clear edges and boundaries** - Signal transitions between more private and more public spaces within the development in order to clearly delineate 'ownership' and communicate to staff which areas they are 'allowed' to use.

10. **Balance cues to naturalness and cues to care** - The landscape in the built up area of the site should communicate a tidy and professional image, but this need not necessitate a dependence on formal, geometric styles. Users tended to prefer slightly more naturalistic treatments. In determining the balance designers should consider what types of organisation the site developers aim to attract.

9.3.1 Open space management recommendations

A number of the key findings on users' experience and perceptions of the open space related to management of the resource rather than elements of its planning and design. These findings suggest a number of management actions that may promote the restorative potential of science park open space. Although developing recommendations for management was not a specific objective of this research, it is worth outlining the conclusions on management and maintenance briefly.

The findings of the qualitative study suggest that the possibilities for interacting with wildlife are an important dimension of the restorative value of the open space on the study sites. This suggests that management actions to promote biodiversity, especially habitat management to attract and promote the more conspicuous mammal and bird species (which play an important part in cueing subjective perceptions of biodiversity), may deliver social as well as environmental benefits. Such management actions could include: control of non-native invasive species in woodland and riparian habitats; leaving standing and fallen dead wood in place in woodland areas (where safe to do so); erecting bird and bat boxes; and incorporating bird feeders and baths in areas visible from indoors. Selective mowing can be a socially acceptable and cost effective way to promote biodiversity whilst maintaining a cared for image; this might include mowing strips around buildings whilst leaving edges unmown, mowing frames around selected strips of meadow, and leaving larger grassy areas in more peripheral, less visible areas of the site unmown. In the case of the latter, seeding such areas with a mix of native meadow flowers may add to their aesthetic appeal.

Employees also favoured a less intensive regime for the management of shrub vegetation; whilst they did not want to see the planted shrubs overgrown, most felt it important to promote a naturalistic aesthetic by avoiding frequent cutting and pruning. However, safety should be paramount in decisions on the intensity of management, particularly for areas around access roads and car parks. The sightlines of road users should be considered in relation to the vegetation - where letting shrubs and hedges grow could compromise visibility more frequent cutting back will be more appropriate. Also in relation to safety, regular maintenance of lighting around buildings and car parking is of key importance for maintaining perceptions of safety outside daylight hours.

9.4 Strengths and limitations of the research design

9.4.1 Key strengths

I would argue that the key strengths of the research lie in: a) its case study design, b) the mixed method approach, and c) the mobile nature of the interview method.

The case study design situated the research in real-world environments. This allowed in-depth investigation of everyday person-environment relationships in science parks - a specific type of development which arguably holds a privileged position in planning policy, but has tended to be studied as property rather than as place. The focus on opportunities for restoration in particular everyday environments encountered by individuals at their workplace resulted in findings high in ecological validity. The situated nature of the research also allowed investigation of how the physical characteristics of particular open spaces influence users' perceptions and experiences of these spaces.

The application of a mixed method design allowed me to capitalise on the strengths of the quantitative and qualitative data collection methods whilst also compensating for their limitations. The collection of quantitative data allowed different factors influencing outcomes such as wellbeing and use patterns to be isolated, shedding light on the complex relationships under investigation. The statistical evidence this yielded is relevant for planning policy; it supports the existing case for investment in greenspace in everyday environments to support health and wellbeing. Also, given the business site context, there are clear implications for economic productivity. Alongside this, the qualitative data allowed rich description and analysis of the subjective experience of these places and how they are used by employees. This revealed some important dimensions of the person-environment relationship not normally captured by the quantitative methods that tend to be favoured in the field of restorative environments research. The evidence of the qualitative study will be of particular relevance to planning and landscape practitioners. Together, the questionnaire and walking interview data therefore complemented each other and allowed the opportunity for triangulating quantitative and qualitative data to achieve a strong all-round understanding of how science park employees relate to the greenspace at their workplace.

Conducting the interviews on the move in the open space itself benefited the research in a number of ways. Firstly, being in the spaces under investigation meant that features of the environment acted to prompt the discussion, which no doubt generated richer data than would have been collected in an indoor setting. Secondly, the outdoor, mobile nature of the process seemed to contribute to creating a relaxed, informal atmosphere which helped in establishing rapport with the participants and stimulated open discussion. This was aided by the fact that the walking routes were (in most cases) determined by the participants; this co-construction of the interview process meant that myself and the participants took joint control of the direction of the discussion.

9.4.2 Limitations of the research design

The cross-sectional nature of the research presents some limitations to the extent that causal inferences can be drawn from the multiple regression modelling. This was unavoidable given the focus of the research on restoration in the everyday context of employees in their own workplaces; there was limited scope for experimental control in this context. The research does, however, build on previous experimental research providing evidence for causal effects of green office window views on employee wellbeing and psychological functioning (reviewed in section 3.2.1). Furthermore, the statistical models were able to account for many other factors that influence wellbeing (e.g. gender, age, socio-economic coping, recent stressful life events, and work demands). Importantly, it also controlled for potential confounding factors in the greenspace-wellbeing relationship. It is thus possible to say with confidence that relationships between workplace greenspace use and wellbeing exist independently of employees' exposure to greenspace in other life domains (i.e. green exercise during leisure time and access to a garden at home). Likewise, the relationship between green views and wellbeing remains after controlling for overall satisfaction with the indoor environment. In this way, it was possible to control for a greater number of potential confounding factors than has previously been the case in research on the wellbeing benefits effects of greenspace at the workplace. However, it is recognised that evidence of a causal restorative effect would have been further strengthened had it been possible to include factors relating to objective indoor lighting conditions. Controlling for absolute levels of physical activity may have also been a useful approach; this was considered during questionnaire design but rejected due to considerations of participant burden. Nevertheless, given previous experimental research in the field (see section

2.2) and recent longitudinal analysis (White et al. 2013b), there is strong evidence that the associations observed in the present study indicate causal relationships.

It was not possible to sample randomly in the participating organisations, however this does not pose a major limitation since all employees in these organisations were invited to participate. There was evidence of a self-selection bias in the sample whereby those in environmental organisations were overrepresented, however awareness of this allowed it to be taken into account in the statistical analysis. This benefited the research as it prompted the analysis of interaction effects, which yielded valuable results regarding individual differences in cumulative effects of workplace greenspace exposure. It is, however, recognised that the modest sample size (although comparing favourably with similar studies) will have limited the power of the statistical tests applied. This may have increased the risk of type II error; it is possible that had a greater sample size been achieved, some of the negative results reported here may have been found statistically significant.

Common to most research investigating wellbeing outcomes, the quantitative study is vulnerable to the limitations associated with self-report data. Given the anonymous nature of the responses there is no *a priori* reason to suspect social desirability responding would have been high, however it cannot be ruled out. Including items in the questionnaire to measure this potential bias would have allowed the possibility of such a bias to be investigated (van de Mortel 2008), however the scope for this was limited given the time constraints on questionnaire completion. Previous research has, however, found social desirability bias in responses to SWEMWBS items to be lower than or similar to other scales measuring wellbeing and mental health (Stewart-Brown et al. 2009). Future research may build on the present study by incorporating objective measures of cumulative effects on employee wellbeing. These might include objective measures of productivity and psychological functioning (though such data would be difficult to capture), or might follow recent advances in the measurement of cumulative effects to overall stress levels by measuring salivary cortisol patterns (Roe et al. 2013).

Related to the above point, it should be recognised that in investigating the immediate, discrete restorative effects of spending time in the workplace greenspace this research has focused on self-reports of employees' conscious experience of restoration. This was the case in both the quantitative and qualitative enquiries into the extent of restorative experiences; both the ROS measure and the walking interviews asked employees about

their perceived experience of restorative effects. However, it could be argued that as the processes in question (attention restoration and stress recovery) are thought to occur unconsciously, self-reports of restoration outcomes may not accurately capture the extent of the benefits. Again future research investigating discrete restoration experiences in workplace open space may benefit from the use of objective measures, e.g. mobile brainwave (EEG) measurement (Aspinall et al. 2013), real-time tracking of blood pressure, and pre-post testing of attentional measures (Hartig et al. 2003). Real-time measures such as mobile EEG methods may also be particularly useful in examining spatial heterogeneity of restorative potential in open spaces.

9.5 Progressing the state of the art

9.5.1 Original contributions of the research

This study is the first to examine the value of workplace greenspace for employee wellbeing in the UK context. In its focus on science park environments it is also the first research to explore how employees use the private open space at peri-urban business sites, and the drivers of and barriers to this use. Because of this emphasis on the end-user, the resulting insights into the patterns of use, and the perceptions and experiences related to this ubiquitous type of open space are of particular relevance to the planning and design professions involved in delivering this type of development.

In contrast to previous international studies of greenspace benefits in the workplace context, this study has considered the different impacts of both use and visual access. It is the first to identify the independent benefits of use and views of greenspace at workplaces on employee wellbeing. It also goes beyond the green versus grey dichotomy previously adopted when considering the wellbeing impacts of views of greenspace from the workplace. In doing this, it has contributed significantly to understanding of how different features of open space design may (or may not) influence the wellbeing benefits gained from viewing greenspace from indoors.

In demonstrating that working in the environmental sector moderates the relationship between wellbeing and exposure to greenspace at the workplace, this research helps to push the research agenda beyond a 'one size fits all' approach to considering workplace greenspace functions in promoting health and wellbeing. This finding is also relevant beyond the workplace context as it contributes to an emerging research agenda

questioning how ecological integrity, and subjective perceptions of this, influences human health and wellbeing through psychological restoration.

Finally, this research demonstrates the value of the walking interview method in investigations of the wellbeing benefits of greenspace. Previous research has investigated greenspace experience in relation to aspects of wellbeing (e.g. social interaction, fear) through the use of mobile methods (Skår 2010, Dinnie et al. 2013). This research adds to the contribution of these studies by explicitly considering the lived experience of greenspace in relation to theories of restorative environments. In doing so the qualitative research element highlights the importance of embodied dimensions of outdoor experience for the wellbeing benefits of greenspace. It could be argued that these aspects of experience are poorly represented in theories on the links between greenspace and psychological wellbeing. This finding challenges the tendency of restorative environments research to conceptualise the experience of the environment as passive perception of external stimuli.

9.5.2 Implications for the future research agenda

This final section summarises the key implications of this study for the future research agenda. Many of these implications apply to the wider field of restorative environments research, whereas others are specific to the topic of interactions with greenspace in the workplace context.

As discussed above, this thesis contends that the wellbeing benefits conferred by the embodied outdoor experience in greenspace are not fully integrated into theories of the wellbeing benefits of greenspace. Further theoretical development might consider whether these constitute a separate mechanism, or whether they can be considered as restorative benefits and might be accommodated by existing theories of restorative environment (or indeed a wider integrated theoretical framework for restorative environments research).

Future empirical work is needed to improve understanding of how individual differences in restoration relate to professional roles, ecological knowledge, and other factors such as connectedness to nature and environmental values. Each of these factors may influence the meaning of particular types of open space to individuals. It will be of particular importance to consider how these factors might influence the impacts of

different open spaces varying in terms of visible human design and management actions, and in biodiversity value.

Furthermore, it will be important for future research to further explore the role of ephemeral qualities of the environment arising out of seasonal changes in the colours, coverage and food sources afforded by vegetation, and temporal variation in light quality and weather conditions. As yet there has been little research focus on how the restorative potential of greenspaces may change over time, but the present research suggests that such ephemeral qualities play a central role in the experience of users. Application of Gibson's (1979) theory of affordances may be a useful approach to such investigations. The opportunity for interacting with wildlife was also found to be a key element influencing the restoration benefits described by users. Future research is needed to build an understanding of the extent to which wildlife and wider aspects of biodiversity impact on wellbeing outcomes in greenspace.

Finally, future research on workplace greenspace could usefully consider how people relate to different types of open space in the workplace context, focusing for example on business parks or industrial sites, or on the use of public greenspaces used by city centre workers of different professions/working in different sectors. As part of the wider research agenda for valuing ecosystem services, attempts to quantify the economic benefits of workplace greenspace in ways that can be easily communicated to stakeholders and the public would be a valuable direction for future research. This research has contributed significantly to the business case for investment in high quality open space in business sites – an important next step may be to identify the economic implications of the benefits to employee wellbeing for business productivity.

Appendix A: Organisation access request letter

Name
Organisation
Address 1
Address 2
Address 3
Address 4

12 May 2011

Dear .....

Science Park greenspace study

I am writing to invite your organisation to take part in an innovative new study on the value of greenspace at the workplace. This research is supported by .....*name of site*....., which is one of four participating study sites in East-Central Scotland.

Science Parks are a relatively new type of business environment where there are unique opportunities for knowledge-sector workers to benefit from access to greenspace during their working day. Studies in other countries have indicated that spending time in a green environment, and having views of nature from the workplace can have measurable effects on wellbeing and productivity. The participation of your employees in this research would permit new insight into these potential benefits in the context of the Science Park environment. This ground-breaking research will be the first in the UK to: a) examine the extent to which viewing and using greenspace at the workplace influences employees' wellbeing and quality of life; and b) explore how Science Park employees use, value and experience the outdoor environment of their workplace.

Your involvement in the study would be very simple and straightforward. It would entail forwarding to your staff on the site an e-mail inviting them to take part in an anonymous online survey, and a later reminder if necessary. I would also require information on the number of staff your organisation has on the site and permission to take photographs of the grounds around your building. Please note that the names of participating organisations will not be published.

The built environment is central to the Scottish Government's strategic objectives to create a healthier, wealthier and greener Scotland. Establishing this evidence base on the value of green work environments is an important step in understanding how best to plan and design business settings that allow both people and businesses to flourish. I hope that .....*name of organisation*... will welcome this opportunity to be involved in this important research. Please let me know by returning the enclosed form in the pre-paid envelope provided, or by informing me via e-mail at kg84@hw.ac.uk. I will be happy to answer any questions you may have.

Yours sincerely,

Kathryn Gilchrist
PhD researcher

Professor Glen Bramley
Head of Institute of Housing, Urban and Real Estate Research (IHURER)

School of the Built Environment
William Arrol Building Heriot-Watt University Edinburgh EH14 4AS United Kingdom
Telephone +44 (0)131 451 8363 Email enquiries@sbe.hw.ac.uk www.sbe.hw.ac.uk

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Appendix B: Employee survey email invitation text

Subject:

<site name> open space study - YOUR VIEWS NEEDED!

Email body:

Dear *<name of organisation>* employee,

How do you feel about the outdoor space or 'open space' around your workplace? I would like to know, and am inviting you to take part in an online survey on this topic. The survey is part of my PhD research at Heriot-Watt University, funded by the Economic and Social Research Council and supported by Greenspace Scotland and the Central Scotland Green Network.

Although previous research has demonstrated how important having access to green environments is for our health and wellbeing, we know very little about the role of greenspace where we work. In this study I want to find out about how people working in Scottish 'Science Park' developments like *<name of site>* use and value the outdoor environment of their workplace, and what they think of the design of the open space on the site. I'll also be exploring whether contact with green environments during the work day affects our health, wellbeing and quality of life. More information about the project is given on the information sheet attached.

Taking part in the survey couldn't be easier – just click on the link below. The survey itself should take no more than 20 minutes to complete, and all responses are anonymous. I hope you will be able to take the time to take part – every single response is extremely valuable, and will be greatly appreciated. You can access the survey here:

<Site-specific survey link>

If you have any problems filling in the survey or have any questions please don't hesitate to contact me – either by e-mail at kg84@hw.ac.uk, or by phone on 0131 451 4601.

Thank you in advance for your time.

Kind regards,

Kathryn Gilchrist

Appendix C: Employee survey

Notes:

Format (e.g. text size, spacing) in this document differs from online version. The online survey can be accessed at:
http://web.sbe.hw.ac.uk/limesurvey/index.php?sid=37153&newtest=Y&lang=en

[M] = Mandatory question
[R] = Response options automatically randomised for each respondent
[F] = Filter question

***<SITE NAME>* OPEN SPACE SURVEY**

Thank you for agreeing to take part in this survey.

The questionnaire will take around 20 minutes to complete. Your responses will be treated confidentially.

Please complete the survey at your usual workstation if possible - it may help for you to be able to see your normal window view to answer some of the questions.

Next>>

A. You and your work

1. What is the name of the building you work in?

2[M]. What is the name of the organisation you work for?

3[M]. Which of these best describes your role within the organisation?

Choose one of the following answers:

- ○ Research
- ○ Administration or financial
- ○ Managerial
- ○ Technical/Professional
- ○ Other:

4. Do you work….?

Choose one of the following answers:

- ○ Full-time
- ○ Part-time

5. How long have you been working at this site?

Choose one of the following answers:

- ○ Less than 1 year
- ○ Between 1 and 3 years
- ○ Between 3 and 5 years
- ○ Between 5 and 10 years
- ○ More than 10 years

6. How satisfied are you overall with….

	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
The indoor environment of your workplace	o	o	o	o	o
The outdoor environment of your workplace	o	o	o	o	o

7 [MF]. Do you do the majority of your work at a particular desk or workstation?*

Choose one of the following answers:

- ○ Yes
- ○ No

*or a particular bench if you work in a lab

Next>>

B. Your view outdoors from your workspace

8. Which floor are you based on?

Choose one of the following answers:

- ○ Basement
- ○ Ground floor
- ○ First floor
- ○ Second floor
- ○ Third floor
- ○ Fourth floor or higher

9 [MF]. How is your desk/workstation oriented?

Check any that apply:

- ☐ I face a window
- ☐ I am side on to a window
- ☐ I have a window behind me
- ☐ I don't have a window in the room I work in

10 [M]. How easy is it for you to see out of the window whilst sitting at your desk/workstation?

Very difficult	Fairly difficult	Neither easy nor difficult	Fairly easy	Very easy
o	o	o	o	o

11[M]. How satisfied are you with the quality of your window view?

Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
o	o	o	o	o

12. Imagine you have taken a photograph of your window view whilst sitting at your desk, and have cut around the window frame. You are left with an image showing only the window itself and what you can see through it. How much of this image would the following features cover?*

	Not present in view	Less than ¼	¼ - ½	½ - ¾	More than ¾	Not sure
Sky	o	o	o	o	o	o
Buildings	o	o	o	o	o	o
Fields and distant countryside	o	o	o	o	o	o
Water features	o	o	o	o	o	o
Lawn/mown grass	o	o	o	o	o	o
Meadow/rough grass	o	o	o	o	o	o
Trees/woodland	o	o	o	o	o	o
Bushes and flowering plants	o	o	o	o	o	o
Footpaths and paved pedestrian areas	o	o	o	o	o	o
Roads and/or car parking	o	o	o	o	o	o
Sculptures, statues or other cultural objects	o	o	o	o	o	o
Blinds or curtains permanently obscuring your view	o	o	o	o	o	o

*if you can see more than one window from your desk please answer for the window you are more likely to look out of

13[M]. How would you describe your view in terms of the balance between natural and built features?*

Completely built	Mostly built	More built than natural	Equally built and natural	More natural than built	Mostly natural	Completely natural
o	o	o	o	o	o	o

*Natural features include vegetation and water, but not sky. Built features include buildings, walls, roads and paved ground, cars, signs etc.

14[M]. How important is it, for you personally, to be able to look out at a pleasant view from your workspace?

Not at all important	Slightly important	Moderately important	Very important	Extremely important
o	o	o	o	o

15. Are there any comments you would like to make about your ability to view the open space from inside or how you feel about your window view?

Next>>

C. Your use of the outdoor space around your workplace

16 [M]. How often do you spend time in the outdoor space around your workplace *in the summer months* (not including passing through on your way in and out of work)?

Choose one of the following answers:

- ○ Every day
- ○ Several times a week
- ○ About once a week
- ○ A few times a month
- ○ About once a month
- ○ Less often
- ○ Never
- ○ Not sure/ not applicable

17 [M]. How often do you spend time in the outdoor space around your workplace *in the winter months* (not including passing through on your way in and out of work)?

Choose one of the following answers:

- ○ Every day
- ○ Several times a week
- ○ About once a week
- ○ A few times a month
- ○ About once a month
- ○ Less often
- ○ Never
- ○ Not sure/ not applicable

18 [M]. *Including* passing through on the way in and out of work, roughly how much time in the course of a week do you spend in the outdoor space *during the summer months*?

Choose one of the following answers:

- ○ Less than 15 minutes
- ○ 15-30 minutes
- ○ 31 minutes – 1 hour
- ○ 1-3 hours
- ○ 3-5 hours
- ○ More than 5 hours
- ○ Not sure/ not applicable

19 [M]. *Including* passing through on the way in and out of work, roughly how much time in the course of a week do you spend in the outdoor space *during the winter months*?

Choose one of the following answers:

- ○ Less than 15 minutes

- ○ 15-30 minutes
- ○ 31 minutes – 1 hour
- ○ 1-3 hours
- ○ 3-5 hours
- ○ More than 5 hours
- ○ Not sure/ not applicable

20[R]. When you choose to spend time outdoors around your workplace, what are your main reasons for doing so?

Please choose at most 3 answers:

- ☐ To get some sun/daylight
- ☐ To get fresh air
- ☐ To enjoy contact with nature
- ☐ To smoke
- ☐ To exercise or keep fit
- ☐ To play sports or games
- ☐ To clear your head and regain focus
- ☐ To relax and/or forget about work hassles
- ☐ To stretch your legs/take a walk
- ☐ For peace and quiet
- ☐ To take in the landscape
- ☐ To eat and drink outside
- ☐ To socialise/chat with others
- ☐ Other:

21. Is there anything that discourages you from using the outdoor space, or that stops you from using it as much as you would like?

Check any that apply:

- ☐ Weather or climate conditions
- ☐ Lack of time
- ☐ Safety concerns
- ☐ Concern that others might think it an inappropriate use of time
- ☐ Too many people in the places I'd like to use
- ☐ Long-term health issues or disability
- ☐ Not having enough places to sit
- ☐ Lack of easy access to areas I'd wish to use
- ☐ I fin the open space unattractive
- ☐ Other:

22. Where is your favourite place to spend time outdoors on or around the <*Science Park/Research Park/Innovation Park/BioCentre as appropriate*>?

23. How often do you spend time in this place?

Choose one of the following answers:

- ○ Every day
- ○ Several times a week
- ○ About once a week
- ○ A few times a month
- ○ About once a month
- ○ Less often
- ○ Not sure/ not applicable

24. When you spend time outdoors during the work day do you mainly do so on your own or with others?

Choose one of the following answers:

- ○ On my own
- ○ With others
- ○ Roughly equal amount of time on my own and with others
- ○ Not sure

Next>>

D. Your attitudes and perceptions of the open space on site

25 [M]. To what extent do you agree or disagree with each of the following statements?

	Strongly disagree	Disagree	Neutral/ Don't know	Agree	Strongly agree
The outdoor environment was something that attracted me to working here	o	o	o	o	o
Compared to other places I have worked the outdoor environment here has many advantages	o	o	o	o	o
I would like to be able to spend more time outdoors here	o	o	o	o	o
Having a green outdoor environment at work is important to me	o	o	o	o	o
The setting of my workplace contributes positively to my overall quality of life	o	o	o	o	o

26 [R]. How would you describe the open space *within* the <*Science Park/Research Park/Innovation Park/BioCentre as appropriate*> itself? Which of the following words would you say apply?

Check any that apply:

☐ Varied	☐ Grey	☐ Accessible	☐ Unnatural
☐ Uniform	☐ Well-maintained	☐ Inaccessible	☐ Distinctive
☐ Attractive	☐ Poorly-maintained	☐ Open	☐ Commonplace
☐ Unattractive	☐ Interesting	☐ Enclosed	☐ Lively
☐ Safe	☐ Boring	☐ Inspiring	☐ Tranquil
☐ Unsafe	☐ Cramped	☐ Depressing	☐ Exciting
☐ Relaxing	☐ Spacious	☐ Quiet	☐ Calming
☐ Stressful	☐ Tidy	☐ Busy	☐ Other:
☐ Green	☐ Untidy	☐ Natural	

27. Are there any outdoor areas within the site that you dislike? If so can you say why?

28. Would you prefer to see more or less of the following features in the open space on the site?

	A lot less	A bit less	It's fine as it is	A bit more	A lot more
Lawn/mown grass	o	o	o	o	o
Meadow/rough grass	o	o	o	o	o
Water features	o	o	o	o	o

Trees/woodland	o	o	o	o	o
Bushes and flowering plants	o	o	o	o	o
Sculpture, statutes or other cultural objects	o	o	o	o	o
Seating and meeting places	o	o	o	o	o
Footpaths and paved pedestrian areas	o	o	o	o	o
Car parking and/or roads	o	o	o	o	o

29. Is there anything else you would change about the open space on site to improve your experience of it, or that would encourage you to spend more time there?

30 M. Think about the *experience* of being outdoors on the site. To what extent do you agree with the following statements?

	Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
I feel calmer after being there	o	o	o	o	o	o	o
After being there I feel restored and relaxed	o	o	o	o	o	o	o
I get new enthusiasm and energy for my everyday routines from spending time there	o	o	o	o	o	o	o
My concentration and alertness clearly increase after being there	o	o	o	o	o	o	o
I can forget everyday worries there	o	o	o	o	o	o	o
Spending time there is a way of clearing and clarifying my thoughts	o	o	o	o	o	o	o

Next>>

E. Your wellbeing and background information

Some of the questions in this final section relate to more sensitive information than that of previous questions. None of these are mandatory, however you are encouraged to answer all questions as this information is vital to this research. As with the rest o this survey, your responses are anonymous and confidential.

31. Are you male or female?

Choose one of the following answers:

- ○ Male
- ○ Female

32. What is your age?

Choose one of the following answers:

- ○ 16-24
- ○ 25-34

- ○ 35-44
- ○ 45-54
- ○ 55+

33. To what extent do you fine your work to be….

	Strongly disagree	Disagree	Neutral/ Don't know	Agree	Strongly agree
Mentally demanding?	o	o	o	o	o
Stressful?	o	o	o	o	o

34. How satisfied are you overall with your job?

Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
o	o	o	o	o

35. In the last 6 months, how many days have you been absent from work due to sickness, ill-health or stress?

[ ]

Only numbers may be entered into this field

36. Below are some statements about feelings and thoughts. Please select the box that best describes your experience of each over the last 2 weeks.

	None of the time	Rarely	Some of the time	Often	All of the time
I've been feeling optimistic about the future	o	o	o	o	o
I've been feeling useful	o	o	o	o	o
I've been feeling relaxed	o	o	o	o	o
I've been dealing with problems well	o	o	o	o	o
I've been thinking clearly	o	o	o	o	o
I've been feeling close to other people	o	o	o	o	o
I've been able to make up my own mind about things	o	o	o	o	o

37. Have you experienced any stressful major life events in the last 6 months?*

Choose one of the following answers:

- ○ Yes
- ○ No

*e.g. bereavement, separation/divorce, redundancy, serious health issues or injury.

38. Which of the following descriptions comes closest to how you feel about your household's income at present?

Choose one of the following answers:

- ○ Living comfortably on present income
- ○ Coping on present income
- ○ Finding it difficult on present income

- ○ Finding it very difficult on present income

39. Do you have access to a private garden at home?

Choose one of the following answers:

- ○ Yes, my house has its own garden
- ○ Yes, but the garden is shared between several households
- ○ No, I don't have a garden at home

40. Weather permitting, how often do you participate in outdoor activities or hobbies in your spare time?*

Choose one of the following answers:

- ○ Every day
- ○ Several times a week
- ○ About once a week
- ○ A few times a month
- ○ About once a month
- ○ Less often
- ○ Never

*This could include (but is not limited to): walking/dog walking, jogging, cycling, gardening, visiting parks/gardens/woodlands etc., hiking or climbing, outdoor sports, nature-based hobbies or conservation work.

Next>>

Submit your answers

You have now come to the end of the survey. Please do not navigate away from this page before clicking the submit button at the bottom of the page.

Would you be willing to take part in the next stage of the research?
I am looking for volunteers who would be willing to be interviewed about their use and perceptions of the open space at their workplace. Interviewees will receive a shopping voucher in thanks for their participation.

If you would be willing to be contacted about taking part in an interview please leave your email address (or your name and phone number) in the box below:

Please note that any contact details you leave here will be stored separately from your survey responses.

If you have any other comments you'd like to make about the open space or this research you can enter them here:

Submit

Appendix D: Project information sheet

Project Information

Finding headspace in green workplaces:
The restorative value of Science Park open space

Researcher:
Kathryn Gilchrist, School of the Built Environment, Heriot-Watt University, Edinburgh.
Funding:
This research is undertaken as part of an Urban Studies PhD in funded by the Environment and Social Research Council (ESRC)

Background to the research:

A significant and growing body of evidence demonstrating the role of greenspace in promoting both physical and mental health has positioned greenspace firmly within Scotland's health agenda. International research on 'restorative environments' has demonstrated that spending time in green environments and viewing natural features in window views can both help to reduce stress and boost recovery from mental fatigue in the short term. In the longer term regular exposure to greenspace can promote wellbeing and cognitive functioning and enhance coping resources. A significant proportion of new commercial property development now occurs at urban-fringe business sites like Science Parks, where low density development and a high quality green environment are prioritised. There is clearly a great deal of scope in these workplaces for employees to benefit from the restorative effects of nature by taking breaks outdoors and through access to window views of greenspace from inside buildings. Furthermore, employees in Science Parks may be a population which experiences especially high drains on their cognitive resources, so opportunities to regain focus and boost mental functioning through these types of restorative experiences may be of particular value in this type of workplace. There are clear implications of this for the wellbeing and productivity of those working in Science Parks and hence also for the businesses located there. However, the evidence base on the restorative value of greenspace in the workplace context is limited, and none of the existing research relates to UK workplaces. This research aims to address this gap.

Research objectives:

- Examine the extent to which viewing and using greenspace at the workplace influences employees' wellbeing and quality of life.
- Explore how employees on Science Parks use, value and experience the outdoor environment of their workplace, with a view to informing the design of future developments to maximise opportunities for psychological restoration.

Data collection methods:

- *Online survey*
  All on-site employees of participating organisations at case study Science Parks will be invited to take part in an anonymous online survey. The survey includes questions on window views, use of the outdoor environment of the workplace, attitudes towards and perceptions of the open space on site, and on wellbeing and background characteristics such as gender, age and job type. Respondents are free to opt out of answering sensitive questions, and all responses will be treated confidentially. The anonymity of participating individuals and organisations will be protected. The survey takes around 20 minutes to complete.

- *One-to-one interviews*
  A smaller number of volunteers from each case study site will also be sought to participate in short semi-structured interviews at a later date. Survey respondents who agree be contacted for an interview will be offered an incentive to participate, and interviews will take place on-site in their own time (during lunch breaks or before/after work).

Any questions? Please address any queries about the research or what participating in the study will involve please feel free contact me at:

Kathryn Gilchrist
William Arrol Building
School of the Built Environment
Heriot-Watt University
Edinburgh EH14 4AS

E-mail: kg84@hw.ac.uk
Telephone: 0131 451 4601
Mobile: 07

Alternatively if you should wish to speak to my PhD supervisor please contact Dr. Caroline Brown
E-mail: C.J.Brown@hw.ac.uk Tel: 0131 451 8224 Address: As above

Appendix E: Interviewee information sheet

INTERVIEWEE INFORMATION SHEET

Project:
Finding headspace in green workplaces: Investigating restorative potential of Science Park open space

Purpose of interview:
The interview element of this ESRC funded PhD project aims to explore how employees on Science Parks *use*, *value* and *experience* the outdoor environment of their workplace. This information will be used to gain insight into the nature of people's relationships with open space at their workplace and to inform recommendations for the planning and design of such sites to maximise opportunities for psychological restoration (stress reduction and restoration from mental fatigue). Study findings will be reported in my PhD thesis and research papers.

Format of interview:
These interviews will be conducted as a 'mobile' or 'walking interview'. The intention is for these interviews to be quite informal, and will involve us taking a walk through the site and chatting as we go. Ideally I would like you to suggest the route – for instance this could be one you like to walk yourself, or that you commonly walk to get somewhere else (like bus stops, shops, catering outlets), or to a place on or close to the site that you enjoy spending time when you can. It would be useful if you could have a think about this prior to the interview. We don't need to spend all of the time walking - we can stop and sit somewhere if you like. Don't worry if you can't think of a route or a place that you'd like to take us - I can suggest one if you prefer.

Duration:
The interview is expected to last up to around 45 minutes; however you are free to choose to end the interview any point. If you would like to continue the discussion after 45 minutes have passed you are more than welcome to do so if you have the time.

Timing:
Interviews must take place in your own time unless your employer has given you express permission to participate during your working hours. It is expected that most interviewees will choose their lunch break as the most convenient time, but if it is better for you to schedule the interview for before or after work, or even on a weekend this is also welcomed. To thank you for giving up some of your free time to take part in the study you will receive a £10 shopping voucher. Both Amazon and 'Love2Shop' vouchers are available (the latter can be redeemed at a range of high street stores), however there is only a limited number of each available so unfortunately I cannot guarantee that there will be a choice.

Confidentiality & Anonymity:
Interview recordings and transcripts will be held in confidence and will not be used other than for the purposes described above. Interview data will be held and used on an anonymous basis. Your data will be held in accordance with the Data Protection Act 1998. Your words may be quoted in the reporting of the research findings; however there will be no mention of your name or the organisation you work for.

Kathryn Gilchrist, William Arrol Building, School of the Built Environment, Heriot-Watt University, Edinburgh, EH14 4AS. E-mail: kg84@hw.ac.uk, phone: 0131 451 4601/07[redacted].

Appendix F: Interview consent form

WALKING INTERVIEW CONSENT FORM

Project:
Finding headspace in green workplaces: The restorative potential of Science Park open space

Consent:
In consenting to participate in a walking interview for the above project I understand that:

1. Taking part in this study is entirely voluntary and I may withdraw my consent at any time.
2. It is my right to decline to answer any question that I am asked.
3. I am free to end the interview at any time.
4. I may request that the interview (or parts thereof) not be recorded.
5. My name and identity will remain confidential in any publications or discussions.
6. My name and organisation will not appear on any recordings or transcripts resulting from the interview.

Please tick and sign below:

I confirm I have read and understood the interviewee information sheet attached ☐

I agree to participate and to the use of my data for the purposes specified ☐

I give permission for an audio recording of the interview to be made ☐

Name (please print): .....

Signature: .....

Date: .....

Signature of researcher: .....

Researcher contact details:
Kathryn Gilchrist, William Arrol Building, School of the Built Environment, Heriot-Watt University, Edinburgh, EH14 4AS. E-mail: kg84@hw.ac.uk, phone: 0131 451 4601.

Appendix G: Interview schedule

Use of the open space	
Building area	Time spent there - how much, when, what doing? Good place for that?
Wider SP area/general outdoor setting	Reasons for choosing route, general use of particular route Use of other areas - how often, how long spent outside Reasons for using the open space (or not) Activities undertaken Social context and preferences for company vs. alone Season and weather effects on use Perceptions of usability of site OS
Organisational culture	Norms and others' use of the space Timing of use during day and perceptions of acceptability (inc. colleagues, management) Work-related activities outdoors - meetings/social events/organised activities
Perceptions and experience	
Building area	What liked/disliked about the immediate area? Perceptions of views from indoors Prefer to work in another area of site?
Wider SP area	How would they describe area presently walking through? Perceptions of different parts of site How does it make you feel walking through here? Why? (prompts: sights, sounds, smells) Feel like still at work/think about work or not when here? Perceptions of buildings, landscaping on site as a whole?
Management and biodiversity	How well managed? Good for biodiversity? Is it important to manage for biodiversity?
Feelings after use	Feelings when returning to work Perceptions of impact of environment where breaks taken
Value of science park workplace	
SP as a workplace	Good things about working at site (prompts: location, travel, setting, facilities) Down sides of working at site (prompts: as above) How does it compare to previous workplaces? Preferred workplace setting
Attachment to GS at work	Does it matter to you to have access to GS/nature at workplace? Why (not)? Would you miss the outdoor setting if you went to work elsewhere?

Appendix H: Modelling impacts of greenspace on wellbeing outcomes

H.1. Open space use and views as predictors of SWEMWBS score - OLS regression

Block 4: Model incorporating use (frequency and duration), view naturalness (natbuilt), view satisfaction (viewsat) and control variables.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.496[a]	.246	.211	3.38570	1.912

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	969.559	12	80.797	7.048	.000
	Residual	2968.904	259	11.463		
	Total	3938.463	271			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	15.423	1.732		8.905	.000		
	Female	**1.092**	**.429**	**.142**	**2.548**	**.011**	.939	1.065
	Age 16-24	2.408	1.266	.107	1.902	.058	.921	1.085
	Income coping	**-.897**	**.278**	**-.179**	**-3.225**	**.001**	.949	1.054
	Based at WSSP	1.246	.686	.101	1.817	.070	.941	1.062
	Outdoor activities	.281	.177	.096	1.584	.115	.799	1.252
	Job mental demands	**.810**	**.274**	**.195**	**2.962**	**.003**	.672	1.488
	Job stress	**-.963**	**.254**	**-.256**	**-3.799**	**.000**	.642	1.558
	Indoor satisfaction	**.461**	**.234**	**.117**	**1.975**	**.049**	.834	1.198
	Use frequency (S)	.050	.146	.023	.342	.732	.630	1.587
	Use duration (S)	**.463**	**.195**	**.155**	**2.376**	**.018**	.683	1.463
	Natbuilt	-.029	.131	-.013	-.222	.824	.817	1.223
	Viewsat	**.802**	**.215**	**.233**	**3.734**	**.000**	.746	1.341

Dependent Variable: SWEMWBS metric score

H.2 Exploring relationships between view heterogeneity and SWEMWBS

H.2.1: Effect of number of different view features on SWEMWBS

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.585[a]	.342	.295	3.15188	2.194

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	940.191	13	72.322	7.280	.000
	Residual	1808.054	182	9.934		
	Total	2748.245	195			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	12.419	1.905		6.518	.000		
	Female	**1.408**	**.496**	**.183**	**2.840**	**.005**	.869	1.151
	Age 16-24	1.868	1.303	.093	1.434	.153	.867	1.153
	Based at WSSP	1.193	.726	.103	1.642	.102	.927	1.078
	Income coping	**-.979**	**.304**	**-.203**	**-3.221**	**.002**	.913	1.095
	Outdoor activities	**.385**	**.181**	**.137**	**2.128**	**.035**	.868	1.152
	Job mental demands	**.726**	**.307**	**.179**	**2.369**	**.019**	.633	1.581
	Job stress	**-.761**	**.298**	**-.200**	**-2.553**	**.011**	.591	1.692
	Indoor satisfaction	**.657**	**.261**	**.159**	**2.523**	**.012**	.905	1.105
	Use duration (S)	**.404**	**.185**	**.140**	**2.182**	**.030**	.884	1.131
	VLawn	**1.303**	**.376**	**.282**	**3.465**	**.001**	.545	1.835
	VTrees	**.587**	**.186**	**.197**	**3.162**	**.002**	.933	1.072
	VBushes	**.678**	**.310**	**.156**	**2.185**	**.030**	.713	1.402
	Viewfeaturesnum	-.069	.138	-.045	-.499	.619	.447	2.238

Dependent Variable: SWEMWBS metric score

H.2.2: Effect of number of different view features on SWEMWBS, natural and built features treated separately

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.588[a]	.346	.296	3.14828	2.188

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ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	953.658	14	68.118	6.873	.000
	Residual	1803.929	182	9.912		
	Total	2757.587	196			

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Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	12.368	1.901		6.507	.000		
	Female	**1.314**	**.516**	**.171**	**2.547**	**.012**	.793	1.260
	Age 16-24	1.763	1.307	.087	1.349	.179	.859	1.164
	Based at WSSP	1.212	.726	.104	1.669	.097	.925	1.081
	Income coping	**-.983**	**.303**	**-.203**	**-3.241**	**.001**	.914	1.094
	Outdoor activities	**.388**	**.181**	**.138**	**2.151**	**.033**	.867	1.153
	Job mental demands	**.714**	**.306**	**.177**	**2.332**	**.021**	.623	1.605
	Job stress	**-.774**	**.296**	**-.205**	**-2.614**	**.010**	.584	1.714
	Indoor satisfaction	**.680**	**.259**	**.166**	**2.621**	**.009**	.895	1.117
	Use duration (S)	**.395**	**.185**	**.136**	**2.136**	**.034**	.884	1.131
	VLawn	**1.373**	**.390**	**.297**	**3.517**	**.001**	.503	1.988
	VTrees	**.609**	**.188**	**.204**	**3.233**	**.001**	.904	1.107
	VBushes	**.700**	**.313**	**.161**	**2.238**	**.026**	.694	1.442
	Builtfeaturesnum	.054	.236	.018	.227	.821	.589	1.699
	Natfeaturesnum	-.222	.266	-.084	-.834	.405	.357	2.804

Dependent Variable: SWEMWBS metric score

H.3 Mediation Analysis - view features, view satisfaction and SWEMWBS

H.3.1: Model 1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.599[a]	.359	.321	3.13827

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1130.289	12	94.191	9.564	.000
	Residual	2018.989	205	9.849		
	Total	3149.278	217			

Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	11.877	1.739		6.830	.000		
Female	**1.715**	**.454**	**.222**	**3.779**	**.000**	.908	1.101
Age 16-24	2.063	1.283	.096	1.608	.109	.883	1.133
Based at WSSP	1.106	.703	.091	1.573	.117	.933	1.072
Income coping	**-1.084**	**.286**	**-.220**	**-3.786**	**.000**	.929	1.077
Outdoor activities	**.439**	**.168**	**.157**	**2.616**	**.010**	.868	1.153
Job mental demands	**.753**	**.287**	**.182**	**2.625**	**.009**	.652	1.533
Job stress	**-.771**	**.271**	**-.202**	**-2.849**	**.005**	.622	1.607
Indoor satisfaction	**.645**	**.237**	**.160**	**2.717**	**.007**	.905	1.105
Use duration (S)	**.368**	**.177**	**.124**	**2.076**	**.039**	.873	1.145
VLawn	**.978**	**.286**	**.206**	**3.417**	**.001**	.858	1.166
VTrees	**.632**	**.175**	**.207**	**3.606**	**.000**	.950	1.053
VBushes	**.885**	**.262**	**.201**	**3.381**	**.001**	.887	1.127

Dependent Variable: SWEMWBS metric score

H.3.2: Model 2

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.549[a]	.302	.263	.927

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	79.457	12	6.621	7.713	.000[b]
1	Residual	183.715	214	.858		
	Total	263.172	226			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
	(Constant)	1.372	.505		2.714	.007		
	Female	.044	.131	.020	.332	.740	.910	1.099
	Age 16-24	-.705	.377	-.113	-1.870	.063	.890	1.124
	Based at WSSP	.172	.196	.052	.879	.381	.937	1.067
	Income coping	.011	.081	.008	.134	.893	.937	1.067
	Outdoor activities	-.049	.049	-.062	-1.019	.309	.890	1.124
	Job mental demands	-.033	.083	-.029	-.405	.686	.645	1.549
	Job stress	-.089	.078	-.083	-1.138	.256	.614	1.628
	Indoor satisfaction	**.360**	**.067**	**.317**	**5.337**	**.000**	.924	1.083
	Use duration (S)	.037	.051	.044	.720	.472	.885	1.130
	VLawn	**.271**	**.079**	**.208**	**3.430**	**.001**	.890	1.124
	VTrees	**.193**	**.050**	**.224**	**3.840**	**.000**	.961	1.041
	VBushes	**.249**	**.075**	**.199**	**3.316**	**.001**	.907	1.102

a. Dependent Variable: View satisfaction

H.3.3: Model 3

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.605[a]	.366	.326	3.12846

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	1152.675	13	88.667	9.059	.000[b]
1	Residual	1996.603	204	9.787		
	Total	3149.278	217			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
	(Constant)	11.379	1.764		6.449	.000		
	Female	**1.695**	**.453**	**.219**	**3.745**	**.000**	.907	1.102
	Age 16-24	2.313	1.290	.107	1.793	.074	.868	1.151
	Based at WSSP	1.082	.701	.089	1.543	.124	.932	1.073
	Income coping	**-1.073**	**.285**	**-.218**	**-3.761**	**.000**	.928	1.077
	Outdoor activities	**.461**	**.168**	**.165**	**2.743**	**.007**	.861	1.161
	Job mental demands	**.760**	**.286**	**.183**	**2.657**	**.009**	.652	1.534
	Job stress	**-.734**	**.271**	**-.192**	**-2.709**	**.007**	.617	1.621
	Indoor satisfaction	**.514**	**.252**	**.127**	**2.037**	**.043**	.797	1.254
	Use duration (S)	**.352**	**.177**	**.119**	**1.988**	**.048**	.870	1.149
	VLawn	**.887**	**.291**	**.187**	**3.042**	**.003**	.821	1.218
	VTrees	**.562**	**.181**	**.184**	**3.109**	**.002**	.888	1.126
	VBushes	**.794**	**.268**	**.180**	**2.966**	**.003**	.842	1.187
	View satisfaction	.353	.233	.101	1.512	.132	.698	1.433

a. Dependent Variable: SWEMWBS metric score

H.4: Moderation analysis - effects of social context of use on use-wellbeing association

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.632[a]	.400	.345	3.03233	2.194

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	931.615	14	66.544	7.237	.000
	Residual	1397.647	152	9.195		
	Total	2329.262	166			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	12.799	2.070		6.183	.000		
	Female	**1.714**	**.507**	**.227**	**3.381**	**.001**	.874	1.144
	Age 16-24	.610	1.543	.028	.395	.693	.796	1.256
	Income coping	**-1.265**	**.311**	**-.268**	**-4.064**	**.000**	.907	1.103
	Based at WSSP	.475	.810	.038	.586	.559	.918	1.090
	Indoor satisfaction	**.928**	**.271**	**.227**	**3.429**	**.001**	.898	1.113
	Outdoor activities	.340	.199	.117	1.709	.089	.841	1.189
	Job mental demands	.428	.318	.106	1.348	.180	.644	1.554
	Job stress	**-.578**	**.298**	**-.153**	**-1.943**	**.054**	.637	1.570
	VTrees	**.673**	**.201**	**.217**	**3.345**	**.001**	.936	1.068
	VLawn	**1.100**	**.324**	**.239**	**3.401**	**.001**	.802	1.246
	VBushes	**.901**	**.305**	**.197**	**2.956**	**.004**	.885	1.130
	CenUDsum	**.766**	**.243**	**.266**	**3.147**	**.002**	.554	1.806
	Socuse	**1.185**	**.516**	**.157**	**2.296**	**.023**	.850	1.177
	CenUDsumXSocuse	**-.858**	**.389**	**-.186**	**-2.207**	**.029**	.556	1.798

Dependent Variable: SWEMWBS metric score

H.5: Moderation analysis - Effects of group and individual differences (envwork and job stress models) on relationships between use/views of greenspace and wellbeing

H.5.1: Environmental sector work interactions

Envwork x Use duration:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.616[a]	.379	.337	3.10279	2.137

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1194.941	14	85.353	8.866	.000
	Residual	1954.337	203	9.627		
	Total	3149.278	217			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	13.219	1.736		7.615	.000		
	Female	**1.763**	**.451**	**.228**	**3.908**	**.000**	.898	1.114
	Age 16-24	1.538	1.287	.071	1.195	.234	.858	1.166
	Income coping	**-1.054**	**.283**	**-.214**	**-3.719**	**.000**	.926	1.080
	Based at WSSP	.843	.704	.069	1.197	.233	.909	1.100
	Outdoor activities	**.389**	**.170**	**.139**	**2.289**	**.023**	.829	1.206
	Job mental demands	**.694**	**.284**	**.168**	**2.441**	**.016**	.648	1.543
	Job stress	**-.706**	**.269**	**-.185**	**-2.625**	**.009**	.616	1.623
	Indoor satisfaction	**.669**	**.236**	**.166**	**2.836**	**.005**	.895	1.118
	VTrees	**.633**	**.173**	**.207**	**3.649**	**.000**	.949	1.054
	VLawn	**1.021**	**.284**	**.215**	**3.598**	**.000**	.853	1.172
	VBushes	**.887**	**.259**	**.201**	**3.425**	**.001**	.885	1.130
	CenUDsum	**.631**	**.203**	**.213**	**3.115**	**.002**	.652	1.534
	Envwork	-.121	.493	-.015	-.245	.807	.870	1.149
	EnvworkxCenUDsum	**-1.010**	**.409**	**-.168**	**-2.469**	**.014**	.662	1.510

Dependent Variable: SWEMWBS metric score

Envwork x Trees in view

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.601[a]	.362	.318	3.14659	2.111

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1139.371	14	81.384	8.220	.000
	Residual	2009.907	203	9.901		
	Total	3149.278	217			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	13.771	1.679		8.204	.000		
	Female	**1.743**	**.458**	**.225**	**3.809**	**.000**	.897	1.115
	Age 16-24	2.092	1.287	.097	1.626	.106	.882	1.133
	Income coping	**-1.092**	**.287**	**-.221**	**-3.804**	**.000**	.928	1.078
	Based at WSSP	1.095	.714	.090	1.533	.127	.908	1.101
	Outdoor activities	**.453**	**.170**	**.162**	**2.666**	**.008**	.851	1.175
	Job mental demands	**.731**	**.289**	**.177**	**2.532**	**.012**	.647	1.546
	Job stress	**-.754**	**.273**	**-.198**	**-2.765**	**.006**	.615	1.626
	Indoor satisfaction	**.653**	**.242**	**.162**	**2.696**	**.008**	.873	1.146
	VLawn	**.977**	**.287**	**.206**	**3.403**	**.001**	.856	1.168
	VBushes	**.853**	**.266**	**.194**	**3.213**	**.002**	.865	1.155
	Use duration (S)	**.386**	**.179**	**.130**	**2.155**	**.032**	.858	1.165
	CenVTrees	**.573**	**.209**	**.187**	**2.740**	**.007**	.672	1.489
	Envwork	-.348	.491	-.042	-.710	.479	.900	1.111
	CenVTreesXEnvwork	.227	.405	.038	.562	.575	.670	1.492

a. Dependent Variable: SWEMWBS metric score

Envwork x Lawn in view:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.620[a]	.385	.342	3.08925	2.117

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1211.955	14	86.568	9.071	.000[a]
	Residual	1937.324	203	9.543		
	Total	3149.278	217			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	13.741	1.758		7.816	.000		
	Female	**1.817**	**.450**	**.235**	**4.040**	**.000**	.896	1.116
	Age 16-24	**2.527**	**1.273**	**.117**	**1.985**	**.049**	.869	1.151
	Income coping	**-1.138**	**.282**	**-.231**	**-4.031**	**.000**	.925	1.081
	Based at WSSP	.924	.698	.076	1.325	.187	.918	1.089
	Outdoor activities	**.395**	**.168**	**.141**	**2.345**	**.020**	.837	1.194
	Indoor satisfaction	**.603**	**.235**	**.149**	**2.569**	**.011**	.897	1.114
	Job mental demands	**.742**	**.282**	**.179**	**2.628**	**.009**	.651	1.535
	Job stress	**-.816**	**.267**	**-.214**	**-3.058**	**.003**	.620	1.613
	VTrees	**.644**	**.173**	**.211**	**3.727**	**.000**	.949	1.054
	VBushes	**.948**	**.259**	**.215**	**3.658**	**.000**	.877	1.141
	Use duration (S)	**.435**	**.177**	**.147**	**2.463**	**.015**	.850	1.177
	CenVLawn	**1.364**	**.314**	**.288**	**4.339**	**.000**	.689	1.452
	Envwork	-.507	.481	-.061	-1.053	.294	.903	1.108
	CenVLawnXEnvwork	**-1.818**	**.646**	**-.185**	**-2.817**	**.005**	.705	1.417

Dependent Variable: SWEMWBS metric score

Envwork x Bushes/flowering plants in view:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.620[a]	.384	.342	3.09040	2.050

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1210.509	14	86.465	9.053	.000
	Residual	1938.770	203	9.551		
	Total	3149.278	217			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	14.118	1.682		8.394	.000		
	Female	**1.697**	**.450**	**.219**	**3.774**	**.000**	.896	1.116
	Age 16-24	1.921	1.265	.089	1.518	.130	.881	1.135
	Income coping	**-1.130**	**.282**	**-.229**	**-4.002**	**.000**	.926	1.080
	Based at WSSP	1.061	.696	.087	1.524	.129	.922	1.085
	Outdoor activities	**.416**	**.168**	**.149**	**2.486**	**.014**	.846	1.183
	Job mental demands	**.668**	**.284**	**.161**	**2.354**	**.020**	.645	1.550
	Indoor satisfactions	**.544**	**.237**	**.135**	**2.299**	**.022**	.884	1.132
	Job stress	**-.823**	**.267**	**-.216**	**-3.081**	**.002**	.619	1.615
	VTrees	**.697**	**.174**	**.228**	**4.004**	**.000**	.934	1.070
	VLawn	**1.076**	**.284**	**.227**	**3.786**	**.000**	.842	1.187
	Use duration (S)	**.423**	**.176**	**.143**	**2.396**	**.017**	.853	1.172
	CenVBushes	**1.228**	**.287**	**.279**	**4.275**	**.000**	.714	1.401
	Envwork	-.565	.484	-.068	-1.167	.244	.894	1.119
	CenVbushesXEnvwork	**-1.698**	**.609**	**-.185**	**-2.789**	**.006**	.688	1.453

Dependent Variable: SWEMWBS metric score

H.5.2: Job stress interactions

Job stress x Use duration:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.602[a]	.363	.322	3.13704	2.135

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1141.710	13	87.824	8.924	.000
	Residual	2007.569	204	9.841		
	Total	3149.278	217			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	10.626	1.755		6.055	.000		
	Female	**1.689**	**.454**	**.218**	**3.719**	**.000**	.906	1.104
	Age 16-24	2.120	1.284	.098	1.652	.100	.881	1.135
	Income coping	**-1.062**	**.287**	**-.215**	**-3.703**	**.000**	.924	1.082
	Based at WSSP	1.148	.704	.095	1.631	.104	.930	1.076
	Outdoor activities	**.440**	**.168**	**.157**	**2.621**	**.009**	.868	1.153
	Job mental demands	**.762**	**.287**	**.184**	**2.658**	**.008**	.652	1.535
	Indoor satisfaction	**.635**	**.237**	**.157**	**2.674**	**.008**	.903	1.107
	VTrees	**.619**	**.176**	**.202**	**3.522**	**.001**	.945	1.058
	VLawn	**.986**	**.286**	**.208**	**3.446**	**.001**	.857	1.166
	VBushes	**.905**	**.262**	**.205**	**3.451**	**.001**	.882	1.133
	CenUDsum	**.360**	**.177**	**.122**	**2.034**	**.043**	.872	1.147
	Cenjobstress	**-.763**	**.271**	**-.200**	**-2.820**	**.005**	.622	1.608
	CenUDsumXCenjobstress	.165	.153	.061	1.077	.283	.970	1.031

Dependent Variable: SWEMWBS metric score

Job stress x Trees in view:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.601[a]	.361	.320	3.14178	2.110

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1135.635	13	87.357	8.850	.000
	Residual	2013.643	204	9.871		
	Total	3149.278	217			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	11.609	1.735		6.690	.000		
	Female	**1.713**	**.454**	**.222**	**3.771**	**.000**	.908	1.101
	Age 16-24	2.006	1.287	.093	1.559	.121	.880	1.137
	Income coping	**-1.070**	**.287**	**-.217**	**-3.726**	**.000**	.925	1.081
	Based at WSSP	1.009	.716	.083	1.409	.160	.901	1.110
	Outdoor activities	**.445**	**.168**	**.159**	**2.642**	**.009**	.866	1.155
	Job mental demands	**.736**	**.288**	**.178**	**2.555**	**.011**	.648	1.543
	Indoor satisfaction	**.635**	**.238**	**.157**	**2.670**	**.008**	.902	1.109
	VLawn	**.950**	**.289**	**.201**	**3.291**	**.001**	.844	1.185
	VBushes	**.864**	**.264**	**.196**	**3.276**	**.001**	.876	1.141
	Use duration (S)	**.360**	**.178**	**.122**	**2.026**	**.044**	.870	1.149
	CenVTrees	**.633**	**.176**	**.207**	**3.605**	**.000**	.950	1.053
	Cenjobstress	**-.772**	**.271**	**-.202**	**-2.851**	**.005**	.622	1.607
	CenVTreesXCenjobstress	.126	.171	.043	.736	.463	.899	1.113

Dependent Variable: SWEMWBS metric score

Job stress x Lawn in view:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.608[a]	.369	.329	3.12046	2.099

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1162.880	13	89.452	9.187	.000
	Residual	1986.398	204	9.737		
	Total	3149.278	217			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	11.383	1.819		6.258	.000		
	Female	**1.669**	**.452**	**.216**	**3.692**	**.000**	.905	1.105
	Age 16-24	2.545	1.303	.118	1.954	.052	.847	1.181
	Income coping	**-1.118**	**.285**	**-.227**	**-3.920**	**.000**	.925	1.081
	Based at WSSP	.944	.705	.078	1.339	.182	.918	1.089
	Outdoor activities	**.427**	**.167**	**.153**	**2.553**	**.011**	.866	1.155
	Job mental demands	**.727**	**.286**	**.176**	**2.546**	**.012**	.651	1.537
	Indoor satisfaction	**.660**	**.236**	**.163**	**2.795**	**.006**	.904	1.107
	VTrees	**.593**	**.176**	**.194**	**3.376**	**.001**	.936	1.068
	VBushes	**.842**	**.261**	**.191**	**3.221**	**.001**	.880	1.137
	Use duration (S)	**.392**	**.177**	**.132**	**2.218**	**.028**	.868	1.152
	Cenjobstress	**-.791**	**.269**	**-.207**	**-2.939**	**.004**	.621	1.610
	CenVLawn	**.935**	**.285**	**.197**	**3.276**	**.001**	.852	1.173
	CenVLawnXCenjobstress	.408	.223	.109	1.829	.069	.878	1.138

Dependent Variable: SWEMWBS metric score

Job stress x Bushes & flowering plants in view:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.610[a]	.372	.332	3.11303	2.097

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1172.323	13	90.179	9.305	.000
	Residual	1976.955	204	9.691		
	Total	3149.278	217			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	11.491	1.751		6.562	.000		
	Female	**1.691**	**.450**	**.219**	**3.756**	**.000**	.907	1.102
	Age 16-24	2.363	1.281	.110	1.845	.067	.872	1.147
	Income coping	**-1.086**	**.284**	**-.220**	**-3.826**	**.000**	.929	1.077
	Based at WSSP	1.144	.698	.094	1.640	.103	.932	1.073
	Outdoor activities	**.429**	**.167**	**.153**	**2.575**	**.011**	.867	1.154
	Job mental demands	**.705**	**.285**	**.170**	**2.469**	**.014**	.648	1.543
	Indoor satisfaction	**.666**	**.236**	**.165**	**2.825**	**.005**	.903	1.107
	VTrees	**.583**	**.176**	**.191**	**3.324**	**.001**	.933	1.072
	VLawn	**.917**	**.285**	**.194**	**3.215**	**.002**	.849	1.178
	Use duration (S)	**.400**	**.176**	**.135**	**2.266**	**.025**	.867	1.154
	CenVBushes	**.896**	**.260**	**.203**	**3.452**	**.001**	.887	1.128
	Cenjobstress	**-.712**	**.270**	**-.187**	**-2.640**	**.009**	.615	1.625
	CenVBushesXCenjobstress	**.486**	**.233**	**.119**	**2.083**	**.039**	.938	1.066

Dependent Variable: SWEMWBS metric score

H.6: Greenspace use and views as predictors of job satisfaction - Ordinal regression

H.6.1. Effects of use (frequency and duration), view naturalness (natbuilt) and view satisfaction (viewsat)

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	672.087			
Final	586.476	85.611	10	.000

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	3123.265	1022	.000
Deviance	585.090	1022	1.000

Pseudo R-Square

Cox and Snell	.281
Nagelkerke	.303
McFadden	.127

Test of Parallel Lines

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	586.476			
General	531.077[a]	55.399[b]	30	.003

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Job satisfaction = 1]	-2.148	.992	4.687	1	.030	-4.093	-.203
	[Job satisfaction = 2]	-.824	.958	.741	1	.389	-2.701	1.053
	[Job satisfaction = 3]	.436	.954	.208	1	.648	-1.435	2.306
	[Job satisfaction = 4]	3.003	.975	9.490	1	.002	1.092	4.914
Location	**Income coping**	**-.351**	**.166**	**4.462**	**1**	**.035**	-.676	-.025
	Job mental demands	**.842**	**.165**	**26.073**	**1**	**.000**	.519	1.165
	Job stress	**-.823**	**.159**	**26.854**	**1**	**.000**	-1.134	-.512
	Indoor satisfaction	**.657**	**.138**	**22.535**	**1**	**.000**	.386	.928
	Use duration (S)	.206	.115	3.197	1	.074	-.020	.432
	Use frequency (S)	-.104	.083	1.574	1	.210	-.268	.059
	Natbuilt	-.021	.078	.070	1	.791	-.174	.133
	Viewsat	.073	.128	.327	1	.567	-.178	.325
	[Age 55+=1]	**1.115**	**.458**	**5.934**	**1**	**.015**	.218	2.013
	[Age 55+=0]	0	.	.	0	.	.	.
	[Lifeevent=1]	-.496	.258	3.682	1	.055	-.1.002	.011
	[Lifeevent=0]	0	.	.	0	.	.	.

Link function: Logit.

H.6.2. Substituting natbuilt and viewsat for view feature types

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	482.999			
Final	387.408	95.592	21	.000

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	670.634	727	.933
Deviance	387.408	727	1.000

Pseudo R-Square

Cox and Snell	.399
Nagelkerke	.432
McFadden	.198

Test of Parallel Lines

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	387.408			
General	290.075[a]	97.333[b]	63	.004

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Job satisfaction = 1]	-.636	1.441	.195	1	.659	-3.459	2.188
	[Job satisfaction = 2]	1.099	1.386	.629	1	.428	-1.617	3.815
	[Job satisfaction = 3]	2.752	1.392	3.906	1	.048	.023	5.481
	[Job satisfaction = 4]	5.562	1.442	14.885	1	.000	2.736	8.387
Location	**Income coping**	**-.447**	**.203**	**4.862**	**1**	**.027**	-.845	-.050
	Job mental demands	**1.036**	**.214**	**23.490**	**1**	**.000**	.617	1.455
	Job stress	**-.989**	**.207**	**22.781**	**1**	**.000**	-1.395	-.583
	Indoor satisfaction	**.782**	**.178**	**19.327**	**1**	**.000**	.433	1.130
	Use frequency (S)	-.155	.104	2.229	1	.135	-.359	.049
	Use duration (S)	**.301**	**.140**	**4.609**	**1**	**.032**	.026	.576
	VBushes	**.457**	**.206**	**4.906**	**1**	**.027**	.053	.861
	VSky	.061	.145	.180	1	.671	-.222	.345
	VBuildings	.161	.174	.858	1	.354	-.180	.503
	VFields	-.150	.243	.382	1	.537	-.626	.326
	VWater	.229	.757	.091	1	.762	-1.255	1.713
	VLawn	-.034	.263	.017	1	.897	-.549	.481
	VMeadow	-.021	.278	.006	1	.940	-.566	.525
	VTrees	.087	.131	.444	1	.505	-.169	.343
	VPaths	.002	.349	.000	1	.995	-.683	.687
	VRoads	-.272	.243	1.257	1	.262	-.748	.204
	VSculture	.176	.468	.142	1	.707	-.741	1.094
	[Age55+=1]	**1.323**	**.647**	**4.180**	**1**	**.041**	.055	2.592
	[Age55+=0]	0	.	.	0	.	.	.
	[Lifeevent=1]	**-.785**	**.334**	**5.507**	**1**	**.019**	-1.440	-.129
	[Lifeevent=0]	0	.	.	0	.	.	.
	[WSSP=1]	.857	.512	2.805	1	.094	-.146	1.861
	[WSSP=0]	0	.	.	0	.	.	.
	[SUIP=1]	**.823**	**.416**	**3.906**	**1**	**.048**	.007	1.639
	[SUIP=0]	0	.	.	0	.	.	.

Link function: Logit.

H.7: Open space use and views as predictors of sickness absence – Logistic regression

H.7.1: Effects of use (frequency and duration), view naturalness (natbuilt) and view (dis)satisfaction (n=282):

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	28.890	10	.001
	Block	28.890	10	.001
	Model	28.890	10	.001

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	228.420[a]	.097	.163

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	**Female (=1)**	**.770**	**.385**	**4.001**	**1**	**.045**	2.161
	Fulltime (=1)	-.745	.495	2.266	1	.132	.475
	SUIPsite (=1)	-.603	.435	1.920	1	.166	.547
	Outactweekly (=1)	**-.953**	**.443**	**4.635**	**1**	**.031**	.385
	Indoorsatisfied (=1)	**-.988**	**.352**	**7.860**	**1**	**.005**	.372
	Socecdiff (=1)	**.830**	**.409**	**4.125**	**1**	**.042**	2.294
	UFyearhi (=1)	**.796**	**.383**	**4.313**	**1**	**.038**	2.218
	UDyearhi (=1)	.307	.362	.716	1	.397	1.359
	Viewdissat (=1)	.380	.468	.659	1	.417	1.463
	Natbuiltbi (=1)	-.114	.356	.102	1	.749	.892
	Constant	-.588	.668	.776	1	.378	.555

H.7.2. Substituting natbuilt and viewdissat with view feature types (n=203):

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	32.644	19	.026
	Block	32.644	19	.026
	Model	32.644	19	.026

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	160.129[a]	.149	.242

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Female (=1)	.867	.484	3.214	1	.073	2.381
	Fulltime (=1)	.074	.687	.012	1	.914	1.077
	SUIPsite (=1)	**-1.704**	**.720**	**5.600**	**1**	**.018**	.182
	Outactweekly (=1)	**-1.032**	**.482**	**4.575**	**1**	**.032**	.356
	Indoorsatisfied (=1)	**-.957**	**.433**	**4.881**	**1**	**.027**	.384
	Socecdiff (=1)	**.990**	**.508**	**3.806**	**1**	**.051**	2.693
	UFyearhi (=1)	.587	.478	1.507	1	.220	1.799
	UDyearhi (=1)	-.015	.447	.001	1	.972	.985
	Skypres (=1)	.217	.905	.058	1	.810	1.243
	Buildingpres (=1)	.180	.509	.125	1	.724	1.197
	Fieldpres (=1)	.259	.622	.173	1	.677	1.295
	Waterpres (=1)	.253	1.246	.041	1	.839	1.288
	Lawnpres (=1)	-.063	.547	.013	1	.908	.939
	Meadowpres (=1)	-.413	.651	.402	1	.526	.662
	Treespres (=1)	-.127	.632	.041	1	.840	.880
	Bushpres (=1)	-.282	.515	.299	1	.584	.754
	Pathpres (=1)	.521	.632	.680	1	.410	1.685
	Roadparkpres (=1)	.426	.613	.484	1	.487	1.532
	Culturpres (=1)	-19.316	14089.630	.000	1	.999	.000
	Constant	-1.349	1.325	1.036	1	.309	.260

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